Prepared for:
Montgomery County Department of Public Works & Transportation
Division of Solid Wastes Services
Rockville, Maryland

FINAL

Fourth Operational Phase (June 2007) Non-Air Media Monitoring for the Montgomery County Solid Waste Resource Recovery Facility Near Dickerson, Maryland

ENSR Corporation
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EXECUTIVE SUMMARY

The Montgomery County, Maryland Solid Waste Resource Recovery Facility (RRF) near Dickerson, Maryland (MD) became operational in the spring of 1995. During the planning process for this facility, residents in the area raised concerns regarding the potential effect(s) of the facility's emissions (primarily dioxins/furans and trace metals) on human health and the environment. In response to these concerns, the County initiated a multi-media monitoring program both before and after the facility became operational. The programs were conducted in both air media and non-air media. This report presents the results obtained in the most recent non-air media monitoring program conducted in 2007 and compares these results with the results obtained in the 1994-95, 96-98, 2001 and 2004 programs. The objective of the non-air media sampling program and this report is to monitor the concentrations of dioxins/furans and trace metals in selected non-air media over time. Concentrations of constituents in non-air media have also been compared to screening benchmarks to provide an indication of the relative concentrations of these constituents. However, this program and this report are not intended to provide a comprehensive risk assessment. The County conducts health risk assessments on a regular basis and decisions regarding the concentrations of constituents relative to health concerns are addressed in detail during the risk assessment process.

The following is a summary of non-air media sampling program events conducted to date:

- Pre-operational phase – sampling conducted over a period of twelve months in 1994-95 before the facility was operational,
- First operational phase - sampling conducted over a period of eighteen months in 1996-98 after full operations commenced in 1995,
- Second operational phase - sampling conducted in the fall of 2001 approximately six years after the RRF became operational,
- Third operational phase - sampling conducted in July-October 2004 approximately nine years after the RRF became operational, and
- Fourth operation phase – sampling conducted in June 2007 approximately twelve years after the RRF became operational.

During the 2007 monitoring program, data were collected to determine the presence of various organic and inorganic chemicals in several media, selected by residents, to represent paths of exposure by residents to these chemicals. Media evaluated in the 2007 sampling effort include hay, cow's milk, farm pond waters, and farm pond fish. In addition, sediment from the farm ponds was included in the monitoring program for 2007. Pond sediment had been sampled in the pre-operational and 1st operational phase monitoring programs but was not sampled in the second or third operational phase monitoring programs. Chemicals analyzed in non-air media samples included polychlorinated dioxins and furans (PCDDs/PCDFs) and selected toxic metals (arsenic, beryllium, cadmium, chromium, lead, mercury, and nickel).

Dioxins and furans are a class of 210 chlorinated organic compounds (i.e., PCDDs and PCDFs). Of these individual chemicals, 17 PCDDs/PCDFs are considered primarily responsible for the health risks and have been assigned risk factors by U.S. EPA. These relative potency factors, known as Toxic Equivalency Factors (TEF), are based upon the relative toxicity of an individual PCDD or PCDF compared to 2,3,7,8-TCDD, the most toxic congener. The overall toxicity of a sample is calculated by multiplying the concentration values for each of the 17 PCDDs/PCDFs by its TEF. The sum of the products of the TEFs and associated congener concentrations then becomes the 2,3,7,8-TCDD toxic equivalency quotient (TEQ), a value which can be used to assess potential risks to human health and the environment. Many of the dioxin/furan results discussed in this report are expressed as TEQ values.

For the second operational (2001) and third operational (2004) phase monitoring programs, detection limits were lower than the pre-operational (1994) and first operational (1996) phase monitoring programs. To provide the highest quality data possible that could be compared to data collected during the previous sampling efforts, specific method detection limits (MDLs) were requested of the laboratories for the 2007 sampling program (4^{th} operational phase). Accordingly, the laboratories obtained MDLs that were comparable to, or lower than the MDLs achieved in 2001 (2^{nd} operational phase) and 2004 (3^{rd} operational phase), and were much lower than the MDLs achieved in the pre-operational and 1^{st} operational phases. Due to lower detection limits, several chemicals that had been previously undetected were detected in 2001, 2004 and 2007. Therefore, presence of these chemicals in more recent (i.e., 2001, 2004 or 2007) data does not suggest that there has been an increase in concentration of such chemicals; rather that the more sensitive and precise methods used for analysis allowed the laboratory to detect and quantify the concentrations which may be lower than the detection limits from previous years monitoring programs.

Undetected congeners are a source of considerable uncertainty; the undetected congener may exist at any level between zero and its laboratory detection limit. When interpreting the results, the actual concentration of the congener may be assumed to be zero, or it may be assumed to exist at the detection limit. For the PCDD/PCDF trend analysis, in the calculation of a TEQ, the congener-specific uncertainty discussed above is compounded by combining (summing) laboratory results for all seventeen congeners—any number of which may be non-detects. Other than stating the assumptions used, there is no “standard” way to handle non-detects in the calculation of TEQ values. To show the range of TEQs that could be calculated depending on the treatment of detection limits, TEQs in the trend analysis were calculated two ways: assuming zero values for all non-detects and assuming non-detects are present at a concentration equal to the detection limit.

This report evaluates the 2007 operational-phase data relative to earlier 1994-95 pre-operational and 1996-98, 2001 and 2004 operational phase sampling events for the chemicals in non-air media samples to determine whether evidence exists that facility operations made a difference in the levels of any of these chemicals in the terrestrial or aquatic environment. The data collected during the 2007 monitoring program are compared to data collected in previous years monitoring programs, and to referenced screening levels. These screening levels are from a variety of sources, including general agricultural literature, U.S. EPA, and the U.S. FDA. Whenever possible, screening levels are medium-specific and indicate a level pertinent to human health (such as an FDA action level) are used to evaluate the data.

The data analysis presented herein suggests no evidence of facility impact upon the presence or concentration of chemicals in the various sample types. The biotic and abiotic media evaluated in this program contain various metals and organic compounds that are part of their native composition and from numerous anthropogenic sources that include coal-fired electric power generating stations, municipal waste combustion facilities, home wood burning and vehicle emissions. Reports from the Centers for Disease Control and Prevention (2005) and U.S. EPA (2005a) indicate that dioxin emissions and resulting ambient levels of dioxins have been on a downward trend in the USA since the 1980’s. Unchanged levels, such as those seen in a variety of the environmental media in this report, may indicate an additional source of dioxin. Since dioxin levels in background have not decreased, it is likely that this potential additional source is a regional, anthropogenic source.

The following is a summary of findings based on review of the data collected in the 2007 monitoring program.

<u>Surface Water</u>

- Pond 2 water quality measurements of pH and dissolved oxygen content were found to be in the normal range and the pond seems to have recovered from the poor water quality readings observed during the 2004 program. The improved water quality of the pond was consistent with improved fishing compared to 2004 as discussed below.

- With the exception of lead and nickel in Pond 2, surface water concentrations of metals were consistent with, or lower than, historical data collected in previous monitoring programs. Lead concentrations in Pond 2 were slightly higher than the data from 2004 and 2001 monitoring programs but lower than the 1994 (pre-operational) and 1996 (1st operational phase) programs. Nickel concentrations in Pond 2 were slightly higher in 2007 compared to 2004, however, the 2007 nickel concentrations were lower than 2001 concentrations as well as 1994 and 1996 data.
- Regardless of the treatment of non-detected congeners, TEQ values are either comparable with or lower than historical sampling results; there is no evidence of any upward trend in PCDD/PCDF (as TEQs).
- In summary, the 2007 metals and PCDD/PCDF concentrations in surface water are consistent with the data collected in previous monitoring programs.

Sediment

- Sediment was sampled from the farm ponds in 2007 for the first time since the 1996 1st operational phase monitoring program and the 1994 pre-operational monitoring program (i.e., only 3 sampling periods thus far).
- Pond 2 sediment concentrations of arsenic, beryllium, and mercury are comparable or lower than historic data collected in previous monitoring programs. Cadmium concentrations measured in 2007 are lower than in 1996, but comparable to 1994. Chromium, lead and nickel concentrations in 2007 are slightly higher than historic data collected in previous monitoring programs.
- Pond 3 sediment concentrations of arsenic, cadmium and mercury are comparable or lower than historic data collected in previous monitoring programs. Beryllium, chromium, lead and nickel concentrations measured in 2007 are slightly higher than historic data.
- Pond 5 sediment concentrations of arsenic, beryllium, cadmium and mercury are comparable or lower than historic data collected in previous monitoring programs. Chromium, lead and nickel concentrations measured in 2007 are slightly higher or comparable to historic data collected in previous monitoring programs.
- When assuming zero value for all non-detected congeners, the TEQ sediment concentrations appear slightly higher in 2007 than in previous years, however, when detection limits are included, the 2007 TEQ concentrations are either consistent with or lower than previous years. This is the case for all three ponds.
- In summary, sediment was sampled from the farm ponds in 2007 for the first time since the 1996 first operational and 1994 pre-operational monitoring programs (three sampling periods), making trend analysis not yet possible. The sediment concentrations of mercury in 2007 were either comparable to, or lower than, historic concentrations. While increases were observed in chromium, nickel and lead, it must be noted that mercury is emitted from the RRF stack in far greater amounts (over 7 times more) than chromium, nickel and lead (see Figure 4-1). While it is recognized that mercury may undergo biotransformation in aquatic environments, one would expect mercury, being emitted at a far greater rate than other metals, would also show an increase in sediment if the stack emissions were contributing to metals loading in the pond sediment, regardless of the form (total mercury was measured in sediment). Since 2007 mercury concentrations in pond sediment are comparable to, or lower than, historic data collected in previous monitoring programs, especially the pre-operational monitoring program, there is no evidence to suggest that the RRF emissions have contributed to the observed increase in chromium, lead and nickel concentrations in sediment. Given the consistent increase in chromium and nickel in the hay from the background location (which is not influenced by RRF emissions), an increase in chromium and nickel concentrations in pond sediment may be attributable to regional ambient air levels and not related to emissions from the RRF. Continued

sampling of pond sediment for metals in future programs will provide additional data for trend analysis.

Hay

- Metals concentrations in hay collected in 2007 from Pond 3 Farm are generally consistent with concentrations detected in previous sampling events for Pond 3 Farm and Kingsbury Dairy Farm. Metals concentrations collected in 2007 from Arthur Johnson Farm are comparable or lower than 2004 data, but consistent with concentrations in hay from Kingsbury Dairy Farm and Pond 3 Farm (Figure 4-13).
- Chromium and nickel concentrations in hay from the background location in Lucketts, Virginia appear to be higher in 2007 than in previous sampling events and have increased since 2001. This trend was not exhibited at either Pond 3 Farm or Arthur Johnson Farm (Figure 4-13). This indicates that other sources in the upwind direction are likely contributing the concentrations of these metals in hay collected from Arthur Johnson Farm and Pond 3 Farm.
- In the case of hay collected at the Pond 3 Farm, when assuming zero for non-detected congeners, the 2007 TEQ results are slightly higher than in 2004 but either consistent with or lower than the 2001 results. When including non-detects in the calculation of TEQs, the 2007 TEQs for hay at this farm are lower than the 2004 results and substantially lower than the 2001 results. In the case of the Arthur Johnson Farm, which was sampled only in the 2004 and 2007 programs, regardless of the treatment of non-detects, the 2007 TEQ values are higher in the 2007 sampling period than in 2004. As there are only two data points, no trend is indicated.
- With respect to the three farms for which hay samples were obtained in three program monitoring periods (Kingsbury '94, '96, '98; Pond 3 Farm '01, '04, '07; and Background '01, '04, '07), TEQ values for succeeding years tend to be either consistent with or lower than prior years, and this is the case regardless of the treatment of non-detected congeners.
- Samples from Arthur Johnson Farm and the background location were dominated by the higher chlorinated, less toxic congeners, particularly OCDD. This congener pattern is consistent with the hay samples from the other farms in this study.
- In summary, the 2007 metals and PCDD/PCDF concentrations in hay from Pond 3 Farm and Arthur Johnson farm are consistent with the data from previous programs. Chromium and nickel concentrations in background hay consistently increased since 2001. This shows that other sources, possibly in the upwind direction, are contributing these metal concentrations.

Milk

- Metals concentrations in milk from 2007 are consistent with, or lower than, historic metals concentrations from previous monitoring programs (Figure 4-14).
- Assuming zero for all non-detected congeners yields an apparent increase in calculated TEQs. However when detection limits are included, lipid-normalized TEQs appear to generally decline over time with 2007 values being either consistent with or slightly higher than 2004 (Figure 4-30).
- PCDD/PCDF detected in the 2007 data were predominately the higher-chlorinated of the dioxin congeners (HxCDD, HpCDD, and OCDD). The lower-chlorinated dioxin congeners (PeCDD and TCDD) were also present, but furan congeners were not detected (Figure 4-30a). Milk collected in previous sampling events, particularly 2001 Arthur Johnson Farm milk, indicates little to no presence of the lower chlorinated dioxin congeners, and an increased presence of all furan congeners (Figure 4-30b). The presence of TCDD and PeCDD in the 2007 milk samples would help explain any higher calculated TEQ values for milk in 2007, since these congeners are more toxic and have high TEFs (Table 3-1).

- Differences between 2001-2007 and 1994-1998 data could also be associated with the change in sampling locations. Milk samples in 2001, 2004 and 2007 were obtained from Arthur Johnson Farm while 1994 and 1996-98 samples were collected from Kingsbury Dairy Farm.

<u>Fish</u>

- Trend analyses for the fish tissue evaluations have assumed that the fish collected are comparable across all sampling events. Fish may accumulate toxic chemicals at different rates, depending on factors such as age, size, feeding guild (i.e., predator or prey fish), temperature, stocking rates, pond size, population density, and amount of nutrition available to the fish. This variability and uncertainty is inherent in field tissue collection, and not all factors can be accounted for in any sampling program. The non-air monitoring sampling program has been designed to help control some of the variability. Fish have been collected from the same ponds throughout the sampling programs. One prey species (bluegill sunfish) and one predator species (largemouth bass) have been targeted from each pond to demonstrate potential differences in accumulation of toxic chemicals in the fish based on feeding guild and size. Although fish age has not been determined for each fish caught, size has been measured. Finally, fish tissue data for dioxins have been adjusted to reflect the fat content of each fish (the lipid-normalization of the data), which helps control for the changing nutrition levels in the ponds.
- Consistent with improved water quality readings, Pond 2 fishing was improved compared to 2004 (eighteen bluegill sunfish were caught during the 2007 field effort).
- Pond 2 metals concentrations in whole body and fillet prey fish are comparable or lower than historic data collected in previous sampling programs. When assuming zero for all non-detects, the TEQs are slightly higher in 2007 than in previous years ('94, '96, and '01). However, when including detection limits, the TEQ s for 2007 are lower than previous years.
- Pond 3 prey and predator fish fillet and whole body samples have concentrations of metals in 2007 that are comparable or lower than historic data collected in previous programs. When assuming zero for all non-detects, TEQ concentrations in fish, particularly bass, are higher than the data collected in previous years. Concentrations of detected PCDDs/PCDFs are comparable for prey fish but higher for predator fish in 2007 compared to previous years. Given that the observed TEQ increase in 2007 based on detected congeners (primarily OCDD) is very low, 5-40 parts per trillion (ppt) (depending on the sample), these differences may be attributable to the natural variations in the ambient environment and/or to the effect of lowered detection limits in 2007. In addition, the largemouth bass sampled was the largest bass (17") caught during the last three programs. A larger, older fish will have accumulated more PCDDs/PCDFs than a younger fish. When detection limits are included, the 2007 Pond 3 fish TEQs are generally consistent with or lower than the previous years.
- Pond 5 prey and predator fish fillet and whole body metals concentrations are consistent with, or lower than, historic data with the exception of nickel in bluegill sunfish fillet, which is slightly higher than 2004 data. No data were available from 2001, 1996 and 1994 programs. In the case of whole body prey tissue, when assuming zero for all non-detects, the TEQ for 2007 are lower than those calculated for 2004 but higher than the 1994 and 1996 values. However, when detection limits are included, the 2007 values are lower than all previous monitoring periods. In the case of predator fillets, when assuming zero for non-detected congeners, the TEQ for 2007 are slightly higher than the two previous monitored years. When detection limits are included, the 2007 TEQ values are slightly higher than the 2004 values, but substantially lower than in 2006. In the case of predator whole body samples, when assuming zero for non-detects, the 2007 TEQ values are consistent with prior years, but when detection limits are included, the 2007 TEQ values are either consistent with or lower than previous years.

- In summary, there were no discernable undesirable trends in metals or PCDD/PCDF concentrations in fish tissue.

The Maryland Department of Natural Resources (DNR) conducted a sampling program in 1993 that included mercury levels in fish collected from several ponds throughout the state. Ponds 2 and 3 were included in the DNR sampling program. Because mercury levels in fish tissue are of particular concern to the residents in the area, these data from the DNR program and the County's programs are summarized in Table ES-1. The locations of the ponds are shown in Figure 2-1.

Conclusions and recommendations of this report are presented in Table ES-2.

Table ES-1 Summary of mercury levels in fish tissue

Parameter	USEPA AWQC	DNR/ VERSAR (1993)	Pond 2 – DNR P10																			
			Bluegill										Largemouth Bass									
			Fillet					Whole Body					Fillet					Whole Body				
			Pre-operational	Operational-phase				Pre-operational	Operational-phase				Pre-operational	Operational-phase				Pre-operational	Operational-phase			
Mercury	0.3	0.08 – 0.12*	1994-95	1996	2001	2004	2007	1994-95	1996	2001	2004	2007	1994-95	1996	2001	2004	2007	1994-95	1996	2001	2004	2007
			<0.1 – 0.13	0.06 – 0.12	0.09 – 0.14	NA	0.06 - 0.07	<0.1	<0.5	0.088 – 0.095	0.07	0.05	0.15	NA	0.18 – 0.21	NA	NA	<0.1	<0.5	0.11 - 0.14	NA	NA

Parameter	USEPA AWQC	DNR/ VERSAR (1993)	Pond 3 – DNR P18																			
			Green Sunfish/Bluegill										Largemouth Bass									
			Fillet					Whole Body					Fillet					Whole Body				
			Pre-operational	Operational-phase				Pre-operational	Operational-phase				Pre-operational	Operational-phase				Pre-operational	Operational-phase			
Mercury	0.3	0.03 – 0.2*	1994-95	1996	2001	2004	2007	1994-95	1996	2001	2004	2007	1994-95	1996	2001	2004	2007	1994-95	1996	2001	2004	2007
		0.14 – 0.15**	No Data	No Data	0.043 – 0.065	0.05 - 0.06	0.07 - 0.08	<0.1	0.055	0.0095 – 0.045	0.04 - 0.05	0.03	NA	NA	0.235	0.15	0.13 - 0.47	NA	NA	0.145	0.06 - 0.1	0.05 - 0.41

Parameter	USEPA AWQC	DNR/ VERSAR (1993)	Pond 5																			
			Bluegill										Largemouth Bass									
			Fillet					Whole Body					Fillet					Whole Body				
			Pre-operational	Operational-phase				Pre-operational	Operational-phase				Pre-operational	Operational-phase				Pre-operational	Operational-phase			
Mercury	0.3	No Data[h]	1994-95	1996	2001	2004	2007	1994-95	1996	2001	2004	2007	1994-95	1996	2001	2004	2007	1994-95	1996	2001	2004	2007
			No Data[b]	No Data[b]	No Data[g]	0.23 - 0.37	0.11 - 0.13	ND (0.1)	0.95	No Data[g]	0.22 - 0.47	0.07 - 0.08	No Data[b]	0.29	No Data[g]	0.19 - 0.28	0.49 - 0.5	ND (0.1) - 0.71	0.35 - 0.70	No Data[g]	0.1 0- 0.19	0.25 - 0.29

Notes:

* Indicates Sunfish or Bluegill Sunfish caught by DNR

** Indicates Largemouth Bass caught by DNR

USEPA Ambient Water Quality Criterion (AWQC) for Mercury (0.3 part per million) indicates the concentration of methyl mercury in fish assumed to be safe for human consumption.

All concentrations in parts per million; milligrams total mercury per kilogram fresh weight tissue.

< = Not detected. Value presented is the detection limit.

NA = No Data – Fish not sampled.

Green sunfish were caught at Lermond Pond in 1994-95 and 1996. Bluegill sunfish were collected in 2001 and 2004. Fish belong to the same genus (*Lepomis*) and, based on taxonomy, trophic level, and size, likely contain similar levels of contaminants.

Table ES-2 Conclusions and recommendations

Chemical	Observations/Conclusions	Recommendations
Polychlorinated dioxins and furans (PCDDs/PCDFs)	No significant change in patterns or concentrations from previous sampling events. Lower detection limits were achieved in 2007, and this is reflected in the higher TEQs in several media when TEQs are calculated assuming zero values for non-detected congeners. When detection limits are included, TEQs are generally consistent with or lower than prior years. Milk is an example of this. TEQs for hay at Arthur Johnson Farm indicate a slight increase over 2004 regardless of treatment of non-detects. However, given only two sample years (2004 and 2007), there is not sufficient evidence for trend evaluation. The pattern of congeners in milk and hay do not reflect the pattern expected to accumulate based on bioconcentration potential of each congener and the emissions from the RRF. Therefore, no evidence to suggest the increase is attributable to RRF emissions.	Continue to monitor at time intervals concurrent with air monitoring (5 years, beginning 2012). Continue to target identical fish species as sampled in 2001, 2004 and 2007. Continue to sample at Pond 2, Pond 3 and Pond 5. Continue to sample sediment to provide adequate data for trend analysis. Continue to sample milk and hay at Arthur Johnson Farm and hay at Pond 3 Farm and the background farm.
Metals: Arsenic, Beryllium, Cadmium, Chromium, Nickel, Lead,	No significant change in patterns or concentrations from previous sampling events. The sediment concentrations of mercury in 2007 were either comparable to, or lower than, historic concentrations observed in previous monitoring programs. While slight increases were observed in chromium, nickel and lead, it must be noted that, mercury is emitted from the RRF in far greater amounts (over 7 times more) than chromium, nickel and lead. Also, 2007 mercury concentrations in sediment are comparable to, or lower than, historical data. Therefore, there is no evidence to suggest that the RRF emissions have contributed to the observed increase in chromium, nickel or lead concentrations. Continued sampling of pond sediment for metals in future programs will provide additional data for trend analysis. None of the other metals in any medium appear to differ significantly from previous sampling events.	Continue to monitor at time intervals concurrent with air monitoring (5 years, beginning 2012). Continue to target identical fish species as sampled in 2001, 2004 and 2007. Continue to sample at Pond 2, Pond 3 and Pond 5. Continue to sample sediment to provide adequate data for trend analysis. Continue to sample milk and hay at Arthur Johnson Farm and hay at Pond 3 Farm and the background farm.
Mercury*	Mercury concentrations in fish continue to be consistent with previous sampling events and have not changed significantly since the RRF became operational. Fluctuations in measured concentrations (Table ES-1) are slight and likely due to natural variations among individual fish.	Continue to monitor at time intervals concurrent with air monitoring (5 years, beginning 2012). Continue to target identical fish species as sampled in 2001, 2004 and 2007. Continue to sample at Pond 2, Pond 3 and Pond 5.
* Mercury is listed separately since it has been of particular concern to the residents living in the area.		

1.0 Introduction

The Montgomery County, Maryland Solid Waste Resource Recovery Facility (RRF), near Dickerson, Maryland (Figure 1-1) became operational in the spring of 1995. During the planning process for this facility, residents in the area expressed concerns regarding the potential human health effects associated with exposure to chemical in the emissions from this facility as they deposit on the surrounding area. Deposition modeling results in the form of isopleths are provided in Appendix A. In response to these concerns, the County initiated a multi-media monitoring program in the vicinity of the facility to monitor the concentrations of various organic and inorganic constituents in abiotic (non-living) and biotic (living) environmental media. This sampling program included an air-monitoring component and a non-air monitoring component. This report presents the results obtained in the most recent non-air media monitoring program conducted in 2007 and compares these results with the results obtained in the 1994-95, 1996-98, 2001 and 2004 programs.

The objective of the non-air media sampling program and this report is to monitor the concentrations of dioxins/furans and trace metals in selected non-air media over time. Concentrations of constituents in non-air media have also been compared to screening benchmarks to provide an indication of the relative concentrations of these constituents. However, this program and this report are not intended to provide a comprehensive risk assessment. The County conducts health risk assessments on a regular basis and decisions regarding the concentrations of constituents relative to health concerns are addressed in detail during the risk assessment process.

The pre-operational phase of the non-air media monitoring was conducted between May 1994 and April 1995 (i.e., time zero monitoring). The pre-operational program was designed to provide baseline data for target chemicals in various non-air media, including (but not limited to) herbaceous crops (hay), farm pond surface water, fish tissue, and bovine (cow) milk. Subsequent to the facility becoming operational, an operational phase non-air media monitoring was conducted in 1996 with limited supplemental data collected in 1998. ENSR conducted an independent review of the data collected in these programs by Roy F. Weston. Because the operational phase non-air media sampling program was conducted only after a year of operation, there was not sufficient time for accumulation of the chemicals sampled in the non-air media (crops, fish, etc.). Therefore, ENSR recommended that future non-air media sampling should be conducted at longer time intervals (a minimum of ten years) to allow sufficient time for accumulation of the sampled chemicals in the non-air media. The County's Dickerson Area Facilities Implementation Group (DAFIG) Air Quality Sub-committee recommended that the program be conducted with a focused scope once every three years based on their conclusion that the non-air media affects the public more directly than the air media. The 2nd operational phase sampling event was conducted by ENSR in 2001, approximately 6 years after the RRF became operational, and the 3rd operational phase sampling event was conducted by ENSR in 2004, approximately 9 years after the RRF became operational. The numbers and types of samples collected during the pre-operational and 1st through 3rd operational phase monitoring are presented in Table 1-1.

The first sampling event during the operational phase of the program (1996-98) provided data for target chemicals in the same environmental media as the pre-operational program (1994-95). Based on the recommendations of the DAFIG Air Quality Sub-Committee, the 2nd and 3rd operational phase sampling programs targeted specific environmental media of concern. These media included water and fish tissue (from two trophic levels) from farm ponds, hay, and cow's milk. Farm pond sediment sampling was re-introduced to the program in the 4th operational phase monitoring program at the recommendation of the DAFIG Air Quality Sub-Committee. This report summarizes the results of the 4th operational phase sampling effort.

The 4th operational sampling effort was conducted June 11 – 13, 2007 (see details in Section 2) approximately 12 years after the RRF became operational. The 4th operational phase sampling was conducted to provide analytical data for trend analysis relative to existing pre-operational and operational phase data. The numbers and types of samples collected in this 4th operational phase event are presented in Table 1-2.

Table 1-1
Number of Historic Target Site/Media/Analyte Samples

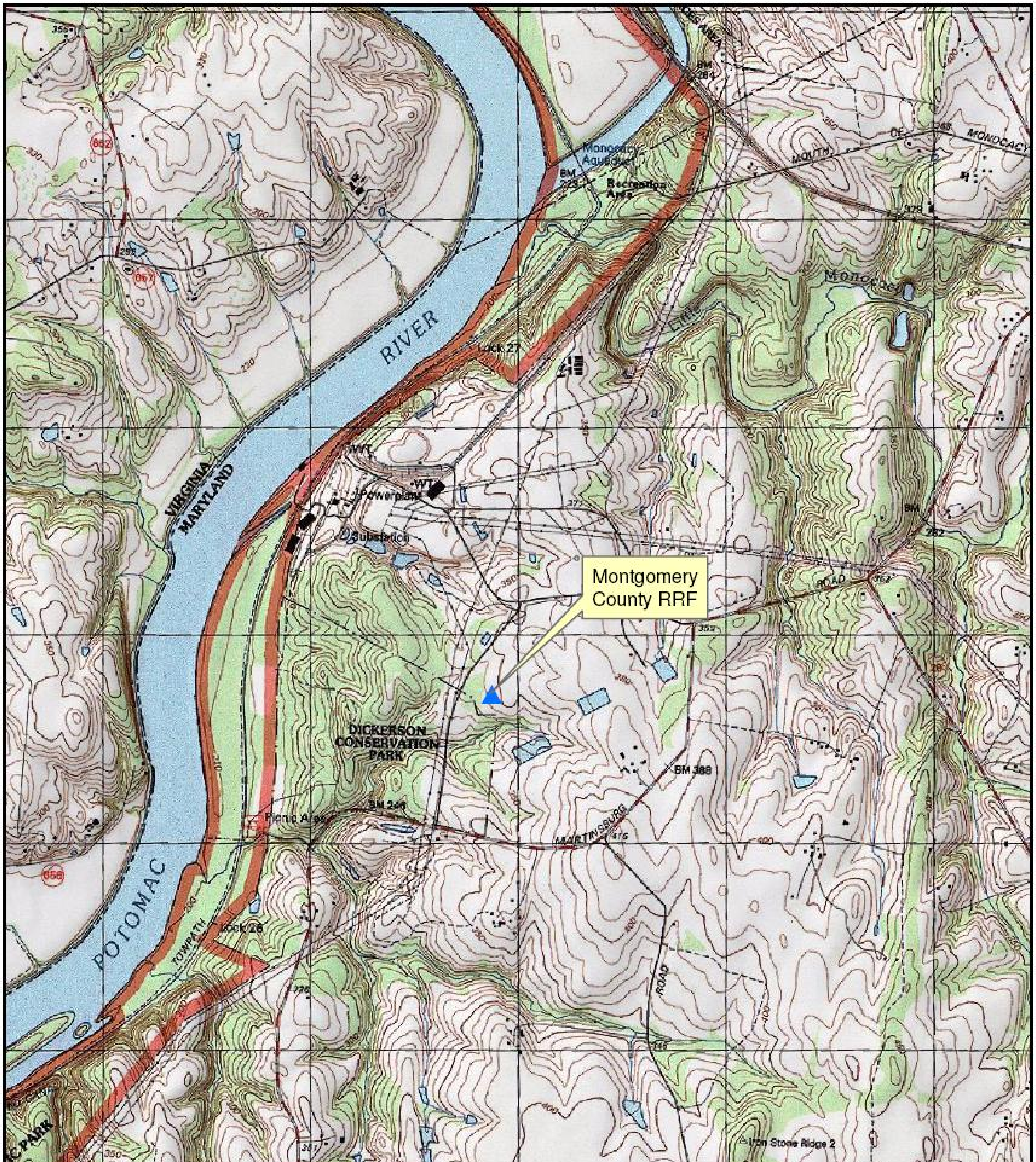
			Location					
			Pond 2	Pond 3	Pond 5	Kingsbury Dairy Farm	Arthur Johnson Farm	Lucketts, VA (background)
METALS								
Surface Water		Pre-Operational: 1994-1995	2	2	2	NA	NA	NA
		1996	2	2	2	NA	NA	NA
		Operational: 2001	2	2	2	NA	NA	NA
		2004	2	2	2	NA	NA	NA
Sediment		Pre-Operational: 1994-1995	2	2	2	NA	NA	NA
		1996	2	2	2	NA	NA	NA
		Operational: 2001	---	---	---	NA	NA	NA
		2004	---	---	---	NA	NA	NA
Bluegill Sunfish	Fillet	Pre-Operational: 1994-1995	2	1[a]	---	NA	NA	NA
		1996	3	1[a]	1[a]	NA	NA	NA
		Operational: 2001	2	2	---	NA	NA	NA
		2004	0	2	2	NA	NA	NA
	Whole Body	Pre-Operational: 1994-1995	1	1[a]	1	NA	NA	NA
		1996	3	1[a]	1[a]	NA	NA	NA
		Operational: 2001	2	2	---	NA	NA	NA
		2004	1	2	2	NA	NA	NA
Largemouth Bass	Fillet	Pre-Operational: 1994-1995	---	---	---	NA	NA	NA
		1996	---	---	---	NA	NA	NA
		Operational: 2001	2	1	---	NA	NA	NA
		2004	0	1	2	NA	NA	NA
	Whole Body	Pre-Operational: 1994-1995	1	---	2	NA	NA	NA
		1996	---	---	---	NA	NA	NA
		Operational: 2001	2	1	---	NA	NA	NA
		2004	0	2	2	NA	NA	NA
Hay		Pre-Operational: 1994-1995	NA	---	NA	5	---	---
		1996	NA	---	NA	5	---	---
		Operational: 2001	NA	2	NA	---	---	---
		2004	NA	2	NA	---	1	1
Milk		Pre-Operational: 1994-1995	NA	NA	NA	4	---	NA
		1996	NA	NA	NA	4	---	NA
		Operational: 2001	NA	NA	NA	---	2	NA
		2004	NA	NA	NA	---	2	NA
DIOXINS								
Surface Water		Pre-Operational: 1994-1995	2	2	2	NA	NA	NA
		1996	3	5	--	NA	NA	NA
		Operational: 2001	2	2	--	NA	NA	NA
		2004	2	2	2	NA	NA	NA
Sediment		Pre-Operational: 1994-1995	2	2	2	NA	NA	NA
		1996	2	2	2	NA	NA	NA
		Operational: 2001	---	---	---	NA	NA	NA
		2004	---	---	---	NA	NA	NA
Bluegill Sunfish	Fillet	Pre-Operational: 1994-1995	2	1[a]	---	NA	NA	NA
		1996	3	1[a]	1[a]	NA	NA	NA
		Operational: 2001	2	2	---	NA	NA	NA
		2004	2	2	2	NA	NA	NA
	Whole Body	Pre-Operational: 1994-1995	1	1[a]	1	NA	NA	NA
		1996	3	1[a]	1[a]	NA	NA	NA
		Operational: 2001	2	2	---	NA	NA	NA
		2004	2	2	2	NA	NA	NA
Largemouth Bass	Fillet	Pre-Operational: 1994-1995	---	---	---	NA	NA	NA
		1996	---	---	---	NA	NA	NA
		Operational: 2001	---	---	---	NA	NA	NA
		2004	---	---	2	NA	NA	NA
	Whole Body	Pre-Operational: 1994-1995	1	---	2	NA	NA	NA
		1996	---	---	---	NA	NA	NA
		Operational: 2001	---	---	---	NA	NA	NA
		2004	---	---	2	NA	NA	NA
Hay		Pre-Operational: 1994-1995	NA	---	NA	5	---	---
		1996	NA	---	NA	3	---	---
		Operational: 1998	NA	---	NA	5	---	---
		2001	NA	2	NA	---	---	1
		2004	NA	2	NA	---	1	1
Milk		Pre-Operational: 1994-1995	NA	NA	NA	4	---	NA
		1996	NA	NA	NA	2	---	NA
		Operational: 1998	NA	NA	NA	4	---	NA
		2001	NA	NA	NA	---	2	NA
		2004	NA	NA	NA	---	2	NA

Notes:
[a] Green Sunfish collected from Pond 3 1994-1995 and 1996.
NA = Not applicable; location not a target for this non-air medium.
"---" = Not sampled

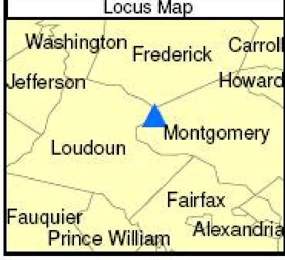
Table 1-2
Number of Samples from 2007 Monitoring Program

Non-Air Medium	2004 Samples	Duplicate and MS/MSD Samples	Location of Sample	Number of Samples per Analyte: PCDD/PCDF	Total Metals	Dissolved Metals	Lipid	Hardness	Total Organic Carbon
Hay	RHH01AA		Lucketts, VA	1	1	N/A	1	N/A	N/A
	LFH01AA-R		Lermond Farm	1	1	N/A	1	N/A	N/A
	LFH01AB-R	LFH01AA DUP	Lermond Farm	0	1	N/A	0	N/A	N/A
	LFH02AA-R		Lermond Farm	1	1	N/A	1	N/A	N/A
	AJH01AA		Arthur Johnson Farm	1	1	N/A	1	N/A	N/A
	AJH02AA		Arthur Johnson Farm	1	1	N/A	1	N/A	N/A
Cow's Milk	AJM01AA	MS/MSD	Arthur Johnson Farm	1	1	N/A	1	N/A	N/A
	AJM02AA		Arthur Johnson Farm	1	1	N/A	1	N/A	N/A
	AJM02AB	AJM01AA DUP	Arthur Johnson Farm	0	1	N/A	0	N/A	N/A
Surface Water	LFSW01AA		Pond 2	1	1	1	N/A	1	N/A
	LFSW02AA		Pond 2	1	1	1	N/A	1	N/A
	LFSW02AB	LFSW02AA DUP	Pond 2	0	1	1	N/A	0	N/A
	EFSW01AA		Pond 3	1	1	1	N/A	1	N/A
	EFSW02AA		Pond 3	1	1	1	N/A	1	N/A
	SLSW01AA		Pond 5	1	1	1	N/A	1	N/A
	SLSW02AA		Pond 5	1	1	1	N/A	1	N/A
Sediment	LFSD01AA		Pond 2	1	1	N/A	N/A	N/A	1
	LFSD02AA		Pond 2	1	1	N/A	N/A	N/A	1
	LFSD02AB	LFSD02AA DUP	Pond 2	0	1	N/A	N/A	N/A	0
	EFSD01AA		Pond 3	1	1	N/A	N/A	N/A	1
	EFSD02AA		Pond 3	1	1	N/A	N/A	N/A	1
	SLSD01AA		Pond 5	1	1	N/A	N/A	N/A	1
	SLSD02AA		Pond 5	1	1	N/A	N/A	N/A	1
Fish Tissue - Fillet	EFBG01AAF		Bluegill sunfish, Pond 2	1	1	N/A	1	N/A	N/A
	EFBG02AAF		Bluegill sunfish, Pond 2	1	1	N/A	1	N/A	N/A
	LFBG01AAF		Bluegill sunfish, Pond 3	1	1	N/A	1	N/A	N/A
	LFBG02AAF		Bluegill sunfish, Pond 3	1	1	N/A	1	N/A	N/A
	LFLMB01AAF		Largemouth bass, Pond 3	1	1	N/A	1	N/A	N/A
	LFLMB02AAF		Largemouth bass, Pond 3	1	1	N/A	1	N/A	N/A
	SLSBG01AAF		Bluegill sunfish, Pond 5	1	1	N/A	1	N/A	N/A
	SLSBG01ABF	SLSBG01AAF DUP	Bluegill sunfish, Pond 5	0	1	N/A	0	N/A	N/A
	SLSBG02AAF		Bluegill sunfish, Pond 5	1	1	N/A	1	N/A	N/A
	SLLMB01AAF		Largemouth bass, Pond 5	1	1	N/A	1	N/A	N/A
	SLLMB02AAF		Largemouth bass, Pond 5	1	1	N/A	1	N/A	N/A
Fish Tissue - Whole Body	EFBG01AAW		Bluegill sunfish, Pond 2	1	1	N/A	1	N/A	N/A
	EFBG02AAW		Bluegill sunfish, Pond 2	1	1	N/A	1	N/A	N/A
	LFBG01AAW		Bluegill sunfish, Pond 3	1	1	N/A	1	N/A	N/A
	LFBG02AAW		Bluegill sunfish, Pond 3	1	1	N/A	1	N/A	N/A
	LFLMB01AAW		Largemouth bass, Pond 3	1	1	N/A	1	N/A	N/A
	LFLMB02AAW		Largemouth bass, Pond 3	1	1	N/A	1	N/A	N/A
	SLSBG01AAW		Bluegill sunfish, Pond 5	1	1	N/A	1	N/A	N/A
	SLSBG01ABW	SLSBG01AAW DUP	Bluegill sunfish, Pond 5	0	1	N/A	0	N/A	N/A
	SLSBG02AAW		Bluegill sunfish, Pond 5	1	1	N/A	1	N/A	N/A
	SLLMB01AAW		Largemouth bass, Pond 5	1	1	N/A	1	N/A	N/A
	SLLMB02AAW		Largemouth bass, Pond 5	1	1	N/A	1	N/A	N/A

N/A = Not applicable for analysis in this medium.
MS/MSD = matrix spike/matrix spike duplicate; QA samples.
DUP = Sample is a field duplicate of sample noted.



Locus Map



Legend

▲ Site Location

N

USGS 1:24,000 Quadrangle
Poolesville, MD

Montgomery County

Figure 1-1
Site Location Map

ENSR | AECOM

Scale 0 0.4 0.8 1.2 1.6 2 Kilometers

2.0 Methods and procedures

Non-air media samples were collected in accordance with the Scope of Work for Conducting the Fourth Operational Phase Non-Air Media Sampling, Spring 2007 (ENSR, 2007; see Appendix B) (SOW). Consistent with the SOW, the following non-air media were the focus of the 2007 sampling event:

- Fish tissue (both whole body and fillet) from farm ponds;
- Farm pond surface water;
- Farm pond sediment;
- Cow's milk; and
- Hay.

The sampling sites for the 2007 field program are shown in Figure 2-1. Five farm ponds were sampled in the pre-operational (1994) and 1st operational phase (1996-1998) events. These ponds were: Pond 1 (Kephart Pond), Pond 2 (Evans Pond), Pond 3 (Lermond Pond), Pond 4 (Yates Pond), and Pond 5 (County Site 2 Pond). Of these five farm ponds, four were monitored in the 2004 field program: Pond 2, Pond 3, Pond 4, and Pond 5. Based on recommendation from the DAFIG Air Quality Sub-Committee, Pond 4 was not included in the 2007 monitoring program. Fish, surface water and sediment were collected from each of the three farm ponds; Pond 2, Pond 3 and Pond 5.

Kingsbury Dairy Farm, which had served as the source for hay and milk in the pre-operational and 1st operational phase events, was no longer operated as a dairy farm in 2001. Therefore, the sites of hay and milk collection were moved to the Pond 3 Farm and Arthur Johnson Farm respectively, in 2001. The Arthur Johnson Farm was selected for milk sampling since it is the closest existing dairy farm in the deposition area of RRF air emissions (see deposition isopleth figures provided in Appendix A). During the 2001, 2004 and 2007 sampling, hay was collected from Pond 3 Farm, Arthur Johnson Farm and a background location in Lucketts, VA, and milk was collected from the Arthur Johnson Farm.

2.1 Field program

Field work was conducted in June 2007. Hay, milk, and water, sediment and fish from Ponds 2, 3 and 5 were sampled June 11 – 13, 2007 (field notes are provided in Appendix F). The primary objective of the sampling program was to obtain measurements of certain target compounds in the environmental media representative of aquatic, terrestrial, and human food chains. The following target media were selected for the 2007 non-air media sampling effort:

- Farm pond surface water;
- Farm pond sediment;
- Farm pond fish tissue (whole body and fillet);
- Herbaceous crops (hay); and
- Cow's milk.

This program supplements the data obtained during previous sampling events. The numbers of samples collected by medium for each target analyte group in 2007 are presented in Table 1-2. The following subsections describe the field sampling effort for each of the target media, and present all deviations from the SOW (ENSR, 2007). The number of samples, including QA/QC samples, collected for the 2007 monitoring event is presented in Table 1-2.

2.1.1 Surface water sampling

As discussed above, water sampling was conducted at three farm ponds: Ponds 2, 3, and 5.

Prior to commencing the surface water sampling effort, water quality parameters were measured using a calibrated water quality meter. These parameters included pH, specific conductance, dissolved oxygen, and temperature. A summary of these measurements is presented in Section 3.

Two surface water samples were collected from each farm pond. To collect the surface water samples, 1-liter (L) amber bottles were submerged while capped, to a few inches below the surface of the water. While submerged, the bottle was uncapped, filled, and recapped while still submerged. The plastic 500 milliliter (mL) bottles for total metals analysis contained nitric acid (HNO_3) as a preservative. These bottles were not submerged in the ponds; an amber bottle was filled and capped as describe above, and then used to fill each plastic bottle. Bottles for dissolved metals analysis did not contain preservative, and were submerged directly into the surface water. Samples were then labeled, put on ice to cool to 4^{o}C, and packed for shipping under chain of custody to the analytical laboratory.

At Pond 2, water quality readings were taken off the dock (to reach a better depth range), and samples were collected a few feet from shore. Two surface water samples (sample numbers EFSW01AA and EFSW02AA) were taken from Pond 2, on June 12, 2007.

At Pond 3, water quality readings and samples were collected mid-pond using the farm owner's row boat. Two surface water samples (samples LFSW01AA and LFSW02AA) and one duplicate sample for metals only (sample LFSW02AB) were taken from Pond 3 on June 12, 2007.

At Pond 5, water quality readings were taken and samples were collected a few feet from shore (no dock or boat was available to access another depth). Two surface water samples (samples SLSW01AA and SLSW02AA) were collected from Pond 5 on June 13, 2007.

2.1.2 Sediment

As discussed above, sediment sampling was conducted at three farm ponds: Ponds 2, 3, and 5. Water quality parameters were measured and water samples were collected prior to obtaining the sediment samples.

Two sediment samples were collected from each farm pond. A pole-mounted Ekman dredge was used to collect the sediment samples where appropriate. If it was not feasible to use the Ekman dredge, sediments were collected using a decontaminated stainless steel spoon or trowel. Sediment recovered from the ponds (using either the Ekman or spoon/trowel) was placed in a decontaminated stainless steel bowl. Sediment was examined for color, texture, odor, and presence of living organisms or detritis. Samples were then labeled, put on ice to cool to 4^{o}C, and packed for shipping under chain of custody to the analytical laboratory.

At Pond 2, one sample was collected a few feet from shore using a trowel and one sample was collected off the dock using an Ekman dredge. Two sediment samples (sample numbers EFSD01AA and EFSD02AA) were taken from Pond 2, on June 12, 2007.

At Pond 3, samples were collected mid-pond from the farm owner's row boat using an Ekman dredge. Two sediment samples (samples LFSD01AA and LFSD02AA) and one duplicate sample for metals only (sample LFSD02AB) were taken from Pond 3 on June 12, 2007.

At Pond 5, samples were collected a few feet from shore (no dock or boat was available to access another depth) using a trowel. Two sediment samples (samples SLSD01AA and SLSD02AA) were collected from Pond 5 on June 13, 2007.

2.1.3 Fish

Prior to initiating the fish tissue sampling program, a scientific collection permit was obtained from the State of Maryland. This permit is provided in Appendix C to this report.

Two species of fish were collected during the 2007 sampling event from the three farm ponds (Ponds 2, 3 and 5). Whole body and fillet fish samples were analyzed. The fillet samples represent the portion of the fish that may be ingested by people. Whole body samples are included to measure the actual concentration in the entire organism.

Target fish species included bluegill sunfish (*Lepomis macrochirus*) and largemouth bass (*Micropterus salmoides*). Bluegill sunfish were selected to represent primary consumer lower trophic level fish and largemouth bass were selected to represent higher trophic level predator fish. These target species were selected for analysis because they: (1) are known to occur in adequate numbers in the man-made farm ponds, (2) represent fish of significant recreational value in the region, (3) represent typical predator and prey fish species, and (4) were collected from these ponds during prior sampling events. Collecting the same species from each pond throughout the monitoring program permits trend analysis evaluation of the fish tissue burden data.

The majority of fish were collected with rod and reel. Fishing using rod and reel at Pond 2 was unproductive. Gill nets were deployed twice for approximately 60 minutes per deployment to obtain the necessary number of fish. When adequate tissue volume was not available for laboratory analysis from a single fish, several fish of the same species were composited at the analytical laboratory. A summary of the fish samples by pond is presented below:

- Eighteen bluegill sunfish were collected from Pond 2. Two were caught using rod and reel. The remaining sixteen were caught using gill nets. The fish were split into two groups of similar size class and composited into two samples (EFBG01AA and EFBG02AA), both analyzed for whole body and fillet tissue. No largemouth bass were collected from Pond 2.
- Three largemouth bass and eight bluegill sunfish were collected from Pond 3. The bluegill sunfish were composited into two samples (LFBG01AA and LFBG02AA, each containing four fish), both analyzed as whole body and fillet tissue. One bluegill sunfish was recovered from the gullet of a largemouth bass. The laboratory removed this fish from the bass and included it in sample LFBG01AA. Two of the three largemouth bass were composited into one sample and used for an MS/MSD sample (LFLMB01AA MS/MSD). The other bass was kept separate (LFLMB02AA). Both largemouth bass samples were analyzed as whole body and fillet tissue.
- Two largemouth bass and fifteen bluegill sunfish were collected from Pond 5. The largemouth bass were kept as separate samples (SLLMB01AA and SLLMB02AA). Both largemouth bass samples were analyzed as whole body and fillet tissue. Three of the bluegill sunfish were released. The remaining twelve bluegill sunfish were composited into three samples (SLBG01AA and its duplicate SLBG01AB containing a total of seven fish and SLBG02AA containing five fish), each analyzed as whole body and fillet tissue.

After capture, all targeted fish were measured and wrapped in hexane rinsed aluminum foil. Individual samples were labeled, placed in separate ziploc bags, and kept on dry ice under chain of custody to be shipped to the analytical laboratory. As described in Section 2.3, no field filleting of fish occurred; all fish tissue preparation was done under laboratory conditions by the contract laboratory, Katahdin Analytical Services. Katahdin then sub-sampled the prepared fish and sent the sub-sample under chain of custody to Axys Analytical Services for dioxin analysis.

2.1.4 Hay

Hay samples for chemical analysis were collected at Pond 3 Farm and Arthur Johnson Farm from rolled bales by cutting an approximately six inch (6") long section, of about two inches (2") in diameter. Hay samples were collected by pulling hay from the bales. At the background location in Lucketts, VA, hay had not yet been harvested and was collected from the field. New sterile Nitrile gloves were used for collecting and handling samples to prevent cross-contamination. Each sample was wrapped in two layers of pesticide-grade hexane rinsed foil, placed in a new labeled ziploc bag, and kept on dry ice under chain of custody to be shipped to the laboratory.

Hay samples were collected from Pond 3 Farm on June 12, 2007. The Pond 3 Farm hay samples include sample numbers LFH01AA-R, LFH01AB-R (duplicate sample of LFH01AA-R) and LFH02AA. Hay samples AJH01AA MS/MSD and AJH02AA were collected from the Arthur Johnson Farm on June 11, 2007.

One hay sample (RHH01AA) was collected at the background site in Lucketts, Virginia on June 11, 2007.

2.1.5 Milk

Milk samples were collected at the Arthur Johnson Farm from a stainless steel holding/churning tank on June 11, 2007. Samples AJM01AA, AJM02AA and AJM02AB (duplicate of AJM02AA) each consisted of one 1L amber glass bottle with no preservatives and one 200 mL plastic bottle with HNO_3 preservative, as prepared by the lab. Sample AJM01AA MS/MSD, associated with AJM01AA, consisted of two additional 200 mL plastic bottles with HNO_3 preservative, as prepared by the laboratory.

Using a clean plastic jug, milk was collected from the mixing tank supply hose, and poured into the bottles. Once filled, the bottles were tightly closed, labeled and put on dry ice under chain of custody for shipping to the laboratory.

2.2 Analytical program

Laboratory services for metals analysis were provided by Katahdin Analytical Services, Scarborough, Maine (Katahdin) and laboratory services for dioxin and furan analysis were provided by Axys Analytical Services, Ltd, Sidney, British Columbia, Canada (Axys). These laboratories were used for the 2004 non-air sampling program. All tissue preparation for hay and fish, including fish filleting, was performed by Katahdin. Katahdin laboratory technicians removed one fillet from each fish, as appropriate, for fillet sample analysis. These samples were then designated using an "F" appended to the sample identification number. The remaining fish was used for whole body analysis, designated using a "W" appended to the sample identification number. The hay and fish fillet and whole body samples were then homogenized individually. Sub-samples of the homogenized tissue samples were sent under chain of custody to Axys.

2.2.1 Laboratory duplicates and matrix spike samples

Laboratory duplicate samples for each medium were analyzed for metals. Matrix spike/matrix spike duplicate (MS/MSD) samples were collected for each medium sampled. A summary of duplicates and MS/MSD samples is provided in Table 1-2.

2.2.2 Analytical parameters

All samples were analyzed for selected total (dissolved plus suspended fractions) and dioxins/furans (i.e., PCDDs/PCDFs [polychlorinated dibenzodioxins and polychlorinated dibenzofurans]). Surface water samples were analyzed for hardness and dissolved metals (arsenic, beryllium, cadmium, chromium, lead, and nickel), sediment samples were analyzed for total organic carbon, and all biotic media samples were analyzed for percent lipid (fat).

2.2.3 Analytical methods

2.2.3.1 Dioxins and furans

The analytical methods used for PCDDs/PCDFs were based on U.S. EPA Method 1613B, Tetra- Through Octa-Chlorinated Dioxins and Furans by Isotope Dilution HRGC/HRMS (U.S. EPA, 1994a). Method 1613B is an approved test method (40 CFR part 136) for use in U.S. EPA's wastewater program for determining dioxins and furans in aqueous, solid, and tissue matrices by isotope dilution, high resolution capillary column gas chromatography (HRGC)/high resolution mass spectrometry (HRMS). The method is used in U.S. EPA's data gathering and monitoring programs associated with the Clean Water Act, the Resource Conservation and Recovery Act (RCRA), the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), and the Safe Drinking Water Act.

To obtain increased resolution of laboratory results for this program, the HRGC/HRMS was calibrated with an extra standard that is five times lower in concentration than the Method 1613B requirement. This allowed the laboratory to report data to a minimum level (ML) five times lower than the method specification. This calibration method has been applied to many projects including the U.S. EPA's National Fish Study (ongoing).

Rigorous extract clean-up procedures, clean procedural blanks and sensitive instruments allow detection of 1 pg TCDD/F per sample. Method 1613B suggests a sample size of 10 grams, thus resulting in a detection limit of 0.1 pg/g. Samples sent to the laboratory for this program were increased to 25 grams, resulting in a detection limit of 0.04 pg/g. This higher sample size option is commonly preferred when evaluating for human health risks (e.g., U.S. EPA National Fish Study).

2.2.3.2 Metals

Arsenic, beryllium, cadmium, chromium, nickel and zinc were analyzed using U.S. EPA Method 6010B, Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES U.S. EPA, 1996). Mercury was analyzed using Method 7470A Mercury in Liquid Waste (Manual Cold-Vapor Technique) (U.S. EPA, 1994b). Both methods are presented in Test Methods for Evaluating Solid Waste, Physical / Chemical Methods (SW-846) (most recent updates available on-line; http://www.epa.gov/epaoswer/hazwaste/test/sw846.htm). SW-846 presents test procedures that U.S. EPA approves and recommends for use in complying with the RCRA Public Law 94-580, as amended. The methods are approved by U.S. EPA to satisfy the data quality requirements of 40 CFR Parts 122 through 270. The methods provided in SW-846 represent the "state-of-the-art in routine analytical tested adapted for the RCRA program" (U.S. EPA, 1994c).

2.2.4 Method detection limits

To provide the highest quality data possible that could be compared to data collected during the previous sampling efforts, specific method detection limits (MDLs) were requested of the laboratories. A list of the lowest reporting limits achieved in previous events for each constituent, in each medium, was provided to the laboratory as the requested MDL. Requested MDLs, as well as MDLs provided in the method literature are listed in Table 2-1.

The analytical laboratories (Katahdin and Axys) reviewed these requested MDLs and provided a list of MDLs that would likely be achieved for these matrices and constituents. MDLs were calculated by the laboratories in accordance with Appendix B of 40 CFR Part 136 (US EPA, 1995). In this procedure, the desired constituent is added a clean laboratory matrix at a concentration close to the estimated MDL, and the concentration of the constituent is measured in a minimum of seven replicate samples of spiked solution. The standard deviation of the results is calculated and multiplied by the appropriate Students *t* factor (3.14 for seven replicates). The resulting value is the level at which the laboratory can differentiate the constituent concentration from zero with 99% confidence. To account for potential matrix interferences and provide a conservative MDL in field collected samples, the calculated MDLs were multiplied by 10 for surface water and 100 for milk to obtain the media-specific MDLs. The MDLs calculated in spiked laboratory soil were assumed to be representative of

MDLs for hay and fish tissue. These MDLs provided by Katahdin and Axys for the non-air media are provided in Table 2-1.

The actual detection limit achieved by the laboratory is dependent on a number of factors, including potential matrix interferences. Organic compounds are particularly sensitive to such interferences. To account for these expected interferences, for each analyte measured in each sample, the sample quantification limit (SQL), was calculated. The SQLs are the limits of quantification at which precision and accuracy are known for each constituent measured in each actual sample and are a multiple (usually three to five times) of the MDL. SQLs are also adjusted for the amount of sample prepared and thus may vary by sample. A summary of SQLs for each medium and target analyte achieved for all sampling events is presented in Table 2-2.

Table 2-1 Method Detection Limits Summary

Metals	Requested MDL			MDL from Literature		MDL provided by Katahdin		
	Water (ppm)	Milk (ppm)	hay/tissue (ppm)	Water (ppm)	Solid (ppm)	water (ppm)	milk (ppm)	hay/tissue/sediment (ppm)
Arsenic	0.0006	0.006	0.14	0.0014	0.6	0.0035	0.035	0.35
Beryllium	0.00034	0.0034	0.037	0.0003	0.1	0.000038	0.00038	0.038
Cadmium	0.00005	0.0005	0.02	0.0005	0.2	0.000035	0.00035	0.035
Chromium	0.00004	0.0004	0.05	0.0009	0.4	0.000192	0.00192	0.192
Lead	0.000022	0.00022	0.015	0.0006	0.3	0.000135	0.00135	0.135
Mercury	0.000007	0.00007	0.003	0.0002	0.08	0.00001	0.0001	0.002
Nickel	0.0014	0.014	0.02	0.0005	0.2	0.00032	0.0032	0.32

Dioxins and Furans	Requested MDL			MDL from Literature		MDL provided by Axys		
	Water (ppq)	Milk (ppq)	hay/tissue (ppt)	Water (ppq)	Solid (ppt)	water (ppq)	Milk (ppq)	Solid (tissue/sediment) (ppt)
2,3,7,8-TCDF	2.122	21.22	0.15	10	1	0.5 - 1	50 - 100	0.05 - 0.1
2,3,7,8-TCDD	1.098	10.98	0.146	10	1	0.5 - 1	50 - 100	0.05 - 0.1
1,2,3,7,8-PeCDF	2.016	20.16	0.308	50	5	0.5 - 1	50 - 100	0.05 - 0.1
2,3,4,7,8-PeCDF	2.3	23	0.409	50	5	0.5 - 1	50 - 100	0.05 - 0.1
1,2,3,7,8-PeCDD	2.176	21.76	0.202	50	5	0.5 - 1	50 - 100	0.05 - 0.1
1,2,3,4,7,8-HxCDF	2.755	27.55	0.204	50	5	0.5 - 1	50 - 100	0.05 - 0.1
1,2,3,6,7,8-HxCDF	1.322	13.22	0.4	50	5	0.5 - 1	50 - 100	0.05 - 0.1
1,2,3,7,8,9-HxCDF	2.182	21.82	0.266	50	5	0.5 - 1	50 - 100	0.05 - 0.1
2,3,4,6,7,8-HxCDF	2.405	24.05	0.255	50	5	0.5 - 1	50 - 100	0.05 - 0.1
1,2,3,4,7,8-HxCDD	2.381	23.81	0.145	50	5	0.5 - 1	50 - 100	0.05 - 0.1
1,2,3,6,7,8-HxCDD	1.519	15.19	0.282	50	5	0.5 - 1	50 - 100	0.05 - 0.1
1,2,3,7,8,9-HxCDD	2.013	20.13	0.248	50	5	0.5 - 1	50 - 100	0.05 - 0.1
1,2,3,4,6,7,8-HpCDF	2.013	20.13	0.601	50	5	0.5 - 1	50 - 100	0.05 - 0.1
1,2,3,4,7,8,9-HpCDF	2.1	21	0.221	50	5	0.5 - 1	50 - 100	0.05 - 0.1
1,2,3,4,6,7,8-HpCDD	2.692	26.92	0.249	50	5	0.5 - 1	50 - 100	0.05 - 0.1
OCDF	8.578	85.78	0.824	100	10	0.5 - 1	50 - 100	0.05 - 0.1
OCDD	22.394	223.94	0.421	100	10	0.5 - 1	50 - 100	0.05 - 0.1

Literature MDLs:
Metals except mercury - EPA Method 200.8
Mercury - SW-846 CVAA
Dioxins/Furans - EPA Method 1613

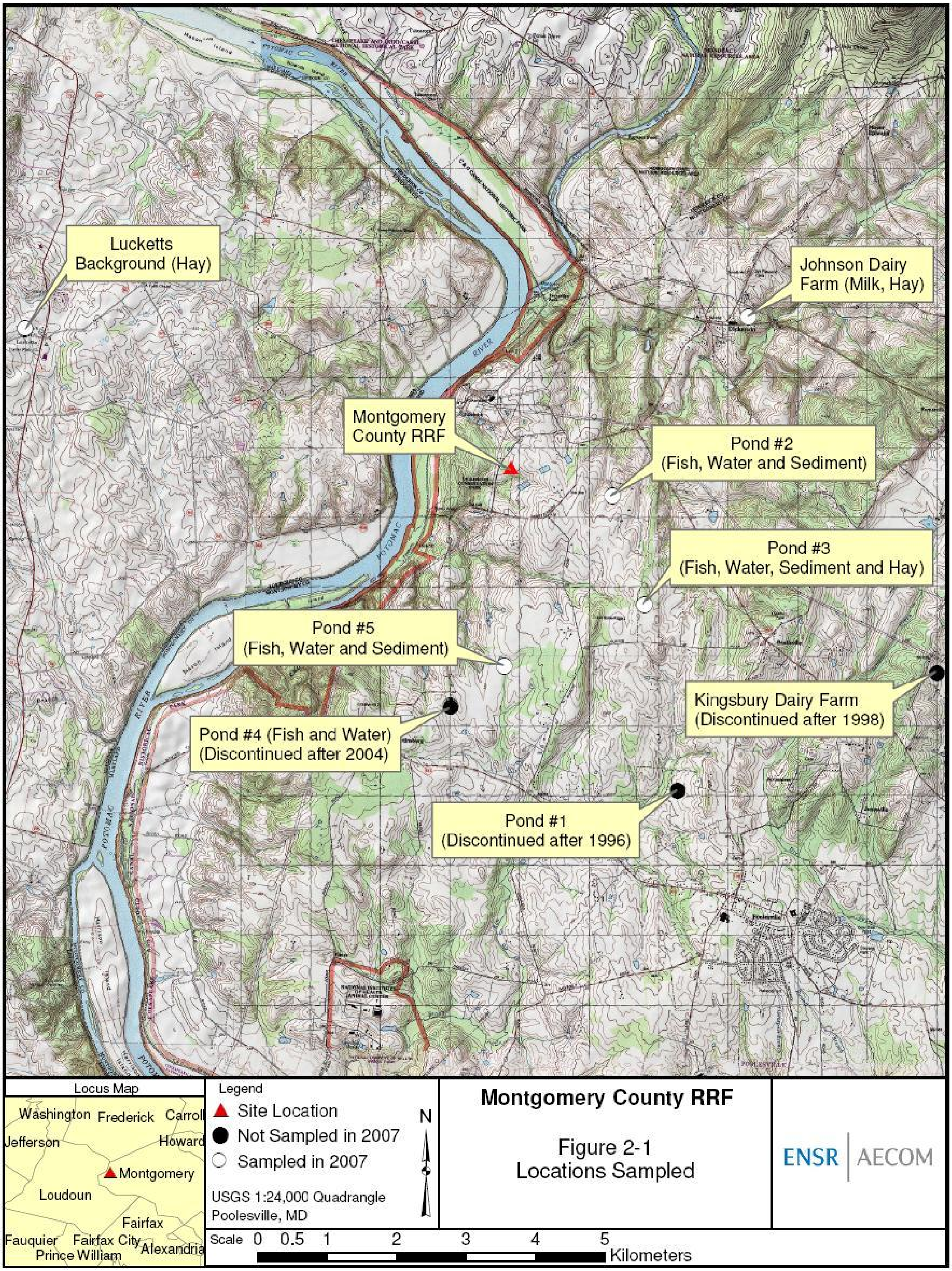
ppm = parts per million; milligrams per liter or milligrams per kilogram
ppq = parts per quadrillion; picograms per liter or nanograms per liter

Table 2-2 Summary of Achieved Detection Limits

Compound (units)		Sample Matrix				
Sampling Event		Surface Water	Sediment	Fish	Hay	Cow's Milk
Dioxins/Furans (ppt)						
Pre-Operational	1994-1995	0.0016 - 0.11	0.22 - 7.8	0.1 - 1.6	0.22 - 5.2	0.02 - 0.38
	1996	0.003 - 0.044	0.46 - 25	0.27 - 3.3	0.19 - 9.1	0.066 - 1.3
	1998	NS	NS	NS	0.1 - 0.5	0.004 - 0.02
Operational	2001	0.00056 - 0.00092	NS	0.068 - 3.3	0.3 - 0.77	0.011 - 0.086
	2004	0.0004 - 0.001	NS	0.1	0.1	0.0125
	2007	0.000508	0.0376	0.0471 - 0.052	0.0449	0.00991
Arsenic (ppm)						
Pre-Operational	1994-1995	0.003	---	0.15	0.15	0.015
	1996	0.003	20.1	11.3	0.5	0.015
Operational	2001	---	NS	0.2	0.2	0.006
	2004	---	NS	0.04 - 0.07	0.07 - 0.08	0.0075
	2007	0.00345	---	0.09	0.14	0.0069
Beryllium (ppm)						
Pre-Operational	1994-1995	0.001	---	0.05	0.05	0.00005
Operational	1996	0.001	0.53	0.3	0.3	0.005
	2001	0.0004	NS	0.04	0.04	0.004
	2004	0.0001	NS	0.01	0.01	0.001
	2007	0.00005	---	0.01	0.01	0.001
Cadmium (ppm)						
Pre-Operational	1994-1995	0.0003	---	0.015	0.015	0.0015
	1996	0.001	0.53	0.2	0.2	0.01
Operational	2001	0.00005	NS	0.02	---	0.0005
	2004	0.0001	NS	0.01	---	0.001
	2007	0.00005	---	0.01	0.01	---
Chromium (ppm)						
Pre-Operational	1994-1995	0.002	---	0.11	0.11	0.006
	1996	0.002	---	0.2	0.2	0.015
Operational	2001	0.0004	NS	---	---	---
	2004	---	NS	---	---	---
	2007	0.00095	---	---	---	---
Lead (ppm)						
Pre-Operational	1994-1995	0.002	---	0.15	0.15	0.015
	1996	0.002	9.4	5.3	5.3	0.01
Operational	2001	---	NS	0.015	---	0.003
	2004	0.00015	NS	---	---	---
	2007	---	---	0.02	---	---
Mercury (ppm)						
Pre-Operational	1994-1995	0.0001	0.16	0.1	0.1	0.0002
	1996	0.0001	0.03	0.05	0.017	0.0005
Operational	2001	0.00005	NS	---	---	0.0001
	2004	0.00001	NS	0.01	0.01	0.00008
	2007	0.00001	---	---	0.01	0.00025
Nickel (ppm)						
Pre-Operational	1994-1995	0.002	---	0.1	---	0.006
	1996	0.003	---	1	1	0.025
Operational	2001	---	NS	---	---	---
	2004	---	NS	---	---	---
	2007	---	---	0.02	---	---

Notes:

ppt = parts per trillion
ppm = parts per million
The achieved detection limita are the sample-specific Practical Quantitation Limits (PQL) achieved by the laboratory
"---" = Not applicable; detected in every sample
NS = Not sampled; no data available



Montgomery County RRF

Figure 2-1
Locations Sampled

3.0 Results

This section presents the results of the 4th operational phase (calendar year 2007) sampling program. The primary objective of the sampling program was to obtain measurements of certain target compounds in the environmental media representative of aquatic and terrestrial food chains. The following target media were selected for the 2007 non-air media sampling effort:

- Farm pond surface water;
- Farm pond sediment;
- Farm pond fish tissue (fillet and whole body);
- Herbaceous crops (hay);
- Cow's milk.

All samples collected were analyzed for dioxins/furans, arsenic, beryllium, cadmium, chromium, nickel, lead, and mercury. Appendix D presents the laboratory analytical data for this program.

Dioxins and furans are a class of chlorinated organic compounds that have been associated with carcinogenic and reproductive effects in humans. Although the term "dioxin" has commonly been associated with one specific chemical, 2,3,7,8-TCDD, there are a total of 210 individual chemicals (congeners) included in the PCDD/PCDF grouping. The dioxin category includes 75 different chemicals sharing a common basic structure with 1 (mono) to 8 (octa) chloride atoms in different positions on the basic structure. The furan category includes 135 different chemicals with 1 to 8 chloride atoms in differing arrangements on a structure slightly different from that of dioxins. Of these 210 individual chemicals, 10 PCDFs and 7 PCDDs with 4 to 8 chloride atoms are considered primarily responsible for the health risks and have been assigned relative potency factors by U.S. EPA. These potency factors, known as Toxic Equivalency Factors (TEFs), are based upon the relative toxicity of an individual PCDD or PCDF compared to 2,3,7,8-TCDD, the most toxic representative.

The overall toxicity of a sample is calculated by multiplying the concentration values for each of the 17 PCDDs/PCDFs by its TEF. The summed products of the TEFs and associated congener concentrations for the sample then becomes a toxic equivalency (TEQ) value which can be used to assess potential risks to human health and the environment.

To facilitate interpretation of the data, the dioxins/furan data presented in this section are expressed as concentrations of the homologues (i.e., the sum of the like individual congeners such as all penta-chlorinated dioxins; PCDD) and as TEQs. Consistent with prior investigations, TEQs were calculated using TEFs updated in 2005 (World Health Organization, 2006). TEFs relate the toxic potency of each congener to 2,3,7,8-TCDD, based on the ability of these compounds to stimulate activity in a liver enzyme in animals (aryl hydrocarbon hydroxylase). TEFs are presented in Table 3-1. Consistent with prior sampling program reports, 2007 TEQs presented in this Section were calculated assuming that non-detected concentrations are equal to zero. In Section 4, where historical results are reviewed and trends over time explored, non-detected congeners are treated in this manner, representing a base assumptions, but also assuming that non-detected congeners were present at laboratory detection limits.

3.1 Screening Levels

To help place the 2007 calendar year field program data into some meaningful context, all data were compared to available medium-specific reference levels. The term adopted for this purpose is "screening levels". When possible, screening levels are presented on a medium-specific basis, and are derived to be protective of human health and/or the environment. These values include Maximum Contaminant Levels (i.e., MCLs and U.S. EPA drinking water standards) and water quality criteria (i.e., levels published by U.S. EPA that indicate a concentration of water considered non-harmful to human health). Health-based MCLs and water quality criteria are important numbers to use as contaminant level guidelines for monitoring potential problems to human health. Since these values are not available for all contaminants in all media, other types of screening levels were also used in the report. These screening levels include values from studies that documented “typical” concentrations of certain contaminants in non-air media, and values from literature that documented concentrations that may have caused a problem in laboratory or field studies.

The screening values used in this report are intended to provide a reference level or guideline for contaminant levels, and are not intended to trigger warning of a potential problem. Exceeding screening levels does not necessarily indicate a potential risk to human health or the environment; rather, it may simply indicate that the site data fall outside of the range of available screening levels. Table 3-2 summarizes the screening levels used in this review. Appendix B of the Roy F. Weston operational phase monitoring report (2000) presents additional information on sources of screening levels used in this review. This previously prepared appendix has been attached as Appendix F to this report. When appropriate, the values compiled by Weston have been updated to reflect current regulatory guidelines.

Some screening values have been updated since the 2004 Monitoring Report. Among these updates include a new water quality criterion for mercury. This updated criterion for mercury, designed to be protective of human health from ingestion of fish, is based on tissue residue (i.e., the water criterion is expressed in terms of the concentration of mercury in fish tissue, rather than in the water column). For the purposes of a screening value with respect to dioxins in milk, the 2004 Monitoring Report made reference to the U.S. EPA primary drinking water standard (MCL) for public water supplied from ground water as its screening level for dioxins in milk. Rather than being health-based, that MCL is a technology-based standard (i.e., it reflects the lowest level to which the EPA found that water treatment technology and resources reasonably could be required to remove the contaminant from ground water). Neither, of course, is that MCL directly applicable milk as MCLs are developed for drinking water. Therefore, in order to provide a more meaningful screening value with respect to dioxins in milk, the current report makes use of the health-based, milk-specific reference standard recently developed by the Commission of the European Communities.

The following sources of information are included in the medium-specific screening level summary (see Table 3-2 and Appendix E):

Surface Water

- *Federal Ambient Water Quality Criteria (AWQC) for Protection of Aquatic Life*. For the purpose of this report, freshwater chronic criteria are presented.
- *Federal AWQC for Human Ingestion of Aquatic Organisms*; and
- *Maryland Toxic Substances Criteria for Ambient Surface Waters*. For the purpose of this report, both human health fish consumption values and aquatic life freshwater chronic values are presented.

Sediment

- *Consensus-Based Sediment Effects Concentrations*. For the purposes of this report and to remain consistent with the 2000 Weston Report which reported on the pre-operational and 1st operational programs, “chronic level” effect screening levels (Threshold Effects Concentrations; TECs) and “acute level” effect screening levels (Probable Effects Concentrations; PECs) are presented; and
- *USEPA Region 3 Freshwater Screening Benchmarks.*

Fish Tissue

- *Federal AWQC for Human Ingestion of Aquatic Organisms* (mercury only); and
- *U.S. EPA (1994) values from Estimating Exposure to Dioxin-Like Compounds (2,3,4,8-TCDD TEQ only).*

Hay

- Various literature values for typical levels of constituents in agricultural crops.

Milk

- Various literature values for typical levels of constituents in cow's milk.
- *Commission of the European Communities, July 1, 2002, Limits on Presence of Dioxin in Food, IP/02/959.*

3.2 Surface water

The water quality measurements taken at each of the three farm ponds are presented in Table 3-3. The results of the chemical analyses are presented in Tables 3-4. As presented in Table 3-2, chronic surface water screening levels for protection of aquatic life were available for all detected metals, and surface water screening levels protective of human consumption of fish were available for TCDD, arsenic, and nickel.

3.2.1 Conventional water quality parameters

At Pond 2, water quality measurements in the shallow pond (approximately 6 feet deep) were within normal range. The pH in Pond 2 was 8.6 (value of 7 being neutral). This is within the range of values that have been observed from this shallow farm pond.

The dissolved oxygen content measurements were high in Pond 2 (7.65 mg/L or 91.7%), but are not super-saturated. Water temperature was 24.4^{o} C. Specific conductivity was 234 μS/cm.

At Pond 3, water quality measurements indicated that the shallow pond (approximately 4 feet deep) was not stratified (Table 3-3). At all depths, temperature, pH, and specific conductance were similar and within the range expected for lotic systems in this geographic region. Temperature did not differ significantly among the strata. Water temperature ranged from 23.5^{o}C to 23.7^{o}C. Specific conductivity and pH were even through the strata, ranging from 129 to 134 μS/cm and 8.1 to 8.7, respectively. Dissolved oxygen in Pond 3 was slightly higher at the surface (5.04 mg/L or 60% saturation) than at mid-depth (3.99 mg/L or 46% saturation). Slightly higher dissolved oxygen at the interface with the air is expected, and dissolved oxygen was not low or depleted in the water column.

Water quality was measured at one foot depth in Pond 5. The water quality data for Pond 5 were in the range previously observed for this small pond. Temperature was 26.6^{o}C, pH was 8.8, dissolved oxygen was 8.99 mg/L (112%), and specific conductivity was 93 μS/cm. The results of the water quality data measurements for all ponds are provided in Table 3-3.

3.2.2 Inorganic constituents (metals)

Table 3-4 presents the inorganic surface water data collected in this program. Duplicate surface water samples were collected at Pond 3. Duplicates were analyzed for metals only. Results described in this section reflect the average concentration of the sample and its duplicate, where applicable.

Historically (1994 through 1998), metals in the non-air media sampling program have been analyzed in surface water as total metals. The dissolved fractions of the metals have been reported in this program. The dissolved fraction (i.e., what remains in the water after the water is filtered) is the fraction that is bioavailable to aquatic life, and therefore potentially toxic. Most water quality criteria are based on the dissolved fraction.

3.2.2.1 Total metals

Total arsenic and mercury were not detected in any surface water samples. Detection limits for these metals in surface water were 3.45 parts per billion (ppb) (arsenic) and 0.01 ppb (mercury). Several constituents in Table 3-4 have concentrations flagged with a "B" (metals) or "K" (dioxins) qualifier. These concentrations are lower than the laboratory's practical quantification limit, but were measured by the instrument. The concentrations flagged by "B" or "K" are detected values, but the actual concentrations are considered "estimated" because they are below the concentrations considered to be statistically definite.

In Pond 2, the maximum concentrations of total beryllium (0.21 ppb), chromium (3.1 ppb), lead (3.4 ppb), and nickel (4.5 ppb) appear higher in one sample from Pond 2 than in the other Pond 2 sample and samples from the other ponds. The lead concentration in the higher Pond 2 sample exceeds the water quality criteria. This could have been due to some sediment that may have been suspended in the water column for the Pond 2 sample.

In Pond 3, total cadmium was detected in one sample at a very low concentration (0.06 ppb). Likewise, total lead was detected in both samples at low concentrations (0.31 and 0.32 ppb). Both lead and cadmium concentrations were far below their respective water quality criteria. Total nickel was detected in both samples, but concentrations were below the water quality criterion.

Total cadmium, chromium, lead and nickel were detected in Pond 5. Concentrations were all lower than their respective criteria and standards.

Consistent with historical data collected in previous monitoring programs, the average hardness in Pond 2 samples (108.5 mg/L as $CaCO_3$) is approximately double the hardness in the other ponds where hardness measurements were 49.45 mg/L as $CaCO_3$ (Pond 3) and 35.3 mg/L as $CaCO_3$ (Pond 5) in 2007.

In summary, the lead concentration measured in one of the Pond 2 samples exceeded the state and federal lead aquatic life chronic screening values. All other metals were either not detected or were detected below the federal and state aquatic life chronic screening values and federal and state water quality criterion for human consumption of organisms.

3.2.2.2 Dissolved metals

Dissolved arsenic, beryllium, chromium and mercury were not detected in any surface water samples. Detection limits for these metals were 3.45, 0.05, 0.95 and 0.01 ppb, respectively. Dissolved nickel was detected in all samples, but the concentrations were one or more orders of magnitude lower than the screening values.

Dissolved lead in Pond 2 (1.4 and 4 ppb) exceeded the federal criterion, and also exceeded the Maryland standard in one sample. These data are slightly anomalous, as the dissolved concentration in EFSW02AA exceeds the total recoverable concentration. Dissolved concentrations that exceed total recoverable concentrations may be counter-intuitive, but is not erroneous. The behavior of metals in surface water can be complicated by organic carbon (particulate and dissolved) and other binding phases. Although the bottles that comprise a single surface water sample (separate bottles for dioxins, total metals and dissolved metals) were collected from a single location at the same time, slight variance at such low levels in surface water is normal.

Dissolved lead in Pond 3 was detected in the samples at concentrations (0.77 – 1.45 ppb) exceeding the aquatic life criterion (0.7 ppb), but not the Maryland standard (2.5 ppb). Further, the dissolved lead concentrations are higher than the total lead concentrations. While anomalous, the concentrations are very low and not significant.

With the exception of lead, none of the concentrations of any of the dissolved metals from Ponds 3, 4, or 5 exceeded federal or state aquatic life chronic screening values or water quality criterion for human consumption of organisms (Table 3-4).

3.2.3 Dioxins/furans

The majority of dioxin and furan congeners were not detected in surface water from the three farm ponds (Table 3-4). The highest detected concentrations were measured for OCDD which ranged from 90 parts per quadrillion (ppq) to 499 ppq in the ponds. The highest OCDD concentration was measured in Pond 5. Other detected congener concentrations were consistent in the ponds.

TEQs were calculated for each surface water sample using two methods; non-detects equal to zero (ND=0) and non-detects equal to the detection limit (ND=DL). In Pond 2 samples, TEQs (ND=0) were 0.198 and 0.432 ppq, and TEQs (ND=DL) were 1.887 and 1.9 ppq. In Pond 3, TEQs (ND=0) were 0.054 and 0.061 ppq, and TEQs (ND=DL) were 1.654 an d1.702 ppq. In Pond 5, TEQs (ND=0) were 0.077 and 0.234 ppq, and TEQs (ND=DL) were 1.817 and 1.904 ppq. All concentrations of TEQ exceeded federal criteria for fish consumption (Table 3-4). None of the concentrations exceeded the state criterion for fish consumption.

3.3 Sediment

Two sediment samples were collected from each of the three ponds. Each sample was analyzed for selected metals, dioxin/furans, and total organic carbon. The results of the chemical analyses are presented in Table 3-5. As presented in Table 3-2, sediment screening benchmarks for protection of wildlife and benthic organisms (i.e., organisms that live in sediment) were available for the metals and TEQ.

3.3.1 Inorganic constituents (metals)

All metals were detected in the sediment samples collected from the three ponds. Concentrations of the metals were generally consistent among the three ponds. None of the metals exceeded their respective screening values.

3.3.2 Dioxins/furans

Most of the dioxin and furan congeners were detected in sediments from the three ponds. Consistent with the surface water congeners, OCDD was present at the highest concentrations, ranging from 1,930 to 6,200 ppt. Both the lowest and the highest OCDD concentrations were found in sediment from Pond 5. TEQs were calculated using two methods; non-detects equal to zero (ND=0) and non-detects equal to the detection limit (ND=DL). Calculated TEQs (ND=0) exceeded the screening benchmark of 0.85 ppt, ranging from 1.8 to 4.2 ppt. Calculated TEQs (ND=DL also exceeded the screening bench, with concentrations ranging from 2.2 to 4.4 ppt.

Non-polar organic constituents such as dioxins/furans bind readily to organic carbon in sediment. This binding renders them unavailable to biological organisms. When constituents are not bioavailable, they are not as toxic or bio-accumulative due to direct contact (i.e., not including ingestion) as when they are freely dissolved in the pore-water of the sediment (i.e., when they are bioavailable). The screening value for TCDD from USEPA Region 3 is normalized to an organic carbon content of 1%. Higher organic carbon would have the effect of increasing the screening value for a system (i.e., a Pond), as the organic constituent present is modified by (bound to) the organic carbon. Organic carbon concentrations were moderate; 1.6% in Pond 2, 4.2% in Pond 3 and 6.85% in Pond 5. At these levels, the dioxin/furans present in the sediment would not be as bioavailable or potentially toxic as indicated by the screening value exceedences.

3.4 Fish tissue residue

Whole body and fish fillet samples from two species of fish were collected from the three ponds. The whole body sample of a largemouth bass from Pond 3 was split and used by Axys for a laboratory duplicate analysis of dioxin/furans. All fish were analyzed for the selected metals, dioxin/furan congeners, and lipid concentrations. Dioxin/furan data are presented in wet weight concentration and lipid normalized concentration for individual congener concentration and TEQs (Table 3-6). Metals data are presented on a wet weight basis only. Fish tissue screening levels were available for TCDD and mercury (Table 3-2).

3.4.1 Inorganic constituents (metals)

Beryllium was not detected in any fish tissue samples from Ponds 2, 3 or 5 (Table 3-6). The detection limit for beryllium was 0.01 ppm wet weight. Arsenic, cadmium, chromium, lead, mercury, and nickel concentrations were detected in at least one fish sample from the three ponds.

All arsenic concentrations in fish were below detection limits with the exception of one whole bluegill sunfish sample in Pond 2 at 0.12 ppm. All cadmium concentrations were below detection limits with the exception of a whole body largemouth bass sample from Pond 3 (0.01 ppm) and two whole body largemouth bass samples from Pond 5 (detected at 0.01 and 0.03 ppm).

The highest concentration of chromium in fish was 0.78 ppm in a whole largemouth bass from Pond 3. The remaining samples ranged from 0.14 to 0.53 ppm in whole bass from Pond 5 and whole bluegill sunfish from Pond 2, respectively. Lead and nickel were highest in whole bluegill sunfish from Pond 2 (0.19 to 0.21 ppm and 0.24 to 0.29 ppm, respectively).

Mercury concentrations were highest in fish from Ponds 3 and 5. In particular, the largemouth bass fillet samples from Pond 5 (0.49 and 0.5 ppm), and the largemouth bass fillet and whole body samples from the 17" fish caught in Pond 3 (0.41 and 0.47 ppm, respectively). These are the only samples that exceeded the U.S. EPA tissue residue-based water quality criterion for mercury (0.3 ppm). Mercury concentrations from other ponds were less than the criterion, with concentrations ranging from 0.05 to 0.07 ppm in Pond 2, 0.03 to 0.13 ppm in Pond 3, and 0.07 to 0.29 ppm in Pond 5

Lipid concentrations for largemouth bass fillet (0.2% - 0.35%) and bluegill sunfish fillet (0.28 – 0.46%) were similar. Lipid concentrations in whole largemouth bass (0.69% - 2.95%) were consistent with the whole bluegill sunfish lipid concentrations (1.37% - 3.66%).

3.4.2 Dioxins/furans

Three furan congeners (1,2,3,7,8-PeCDF, 1,2,3,6,7,8-HxCDF and 1,2,3,7,8,9-HxCDF) were not detected in any fish tissue from the three ponds. Detection limits for these dioxin and furan congeners ranged from 0.0471 to 0.052 ppt. TEQs were calculated using two methods; non-detects equal to zero (ND=0) and non-detects equal to the detection limit (ND=DL).

<u>TEQs (ND=0)</u>

Wet weight TEQs (i.e., the amount of dioxin, as TEQs, present per weight of the fish whole body or fillet) were varied among the fish collected from the ponds, but were slightly higher in whole body fish from Pond 5. Whole body wet weight TEQs concentrations were: 0.184 – 0.285 ppt (bluegill sunfish) in Pond 2; 0.163 – 0.320 ppt (bluegill sunfish) and 0.252 - 0.303 ppt (bass) in Pond 3; and 0.45 – 0.475 ppt (bluegill sunfish) and 0.535 – 0.536 ppt in Pond 5 (refer to Table 3-6). Fillet wet weight TEQs for bluegill sunfish were similar in

Ponds 2, 3 and 5, ranging from 0.0012 ppt (bluegill sunfish Pond 3) to 0.096 ppt wet weight (bluegill sunfish Pond 5). The largemouth bass fillet samples from Pond 5 were slightly higher than the other fish (0.134 and 0.243 ppt). The slightly higher concentration of dioxin/furans in fish from Pond 5 is consistent with the results from the 2004 data.

With the exception of one bluegill sunfish fillet sample from Pond 2 (24.90 ppt lipid) and one bluegill sunfish fillet sample from Pond 3 (0.41 ppt lipid), lipid-normalized TEQs (i.e., the amount of dioxin, as TEQs, present per amount of fat in the fish whole body or fillet) appear to be consistent for bluegill sunfish in Ponds 2, 3, and 5 (Table 3-6). Largemouth bass lipid-normalized TEQs were also generally consistent between Ponds 3 and 5 (no bass were caught in Pond 2), ranging from 18.17 ppt lipid (whole bass in Pond 5) to 69.46 ppt lipid (largemouth bass fillet in Pond 5).

<u>TEQs (ND=DL)</u>

Wet weight TEQs (i.e., the amount of dioxin, as TEQs, present per weight of the fish whole body or fillet) were varied among the fish collected from the ponds, but were slightly higher in whole body fish from Pond 5. Whole body wet weight TEQs concentrations were: 0.231 – 0.327 ppt (bluegill sunfish) in Pond 2; 0.208 – 0.338 ppt (bluegill sunfish) and 0.279 - 0.324 ppt (bass) in Pond 3; and 0.476 – 0.522 ppt (bluegill sunfish) and 0.558 – 0.566 ppt in Pond 5 (refer to Table 3-6). Fillet wet weight TEQs for bluegill sunfish were similar in Ponds 2, 3 and 5, ranging from 0.152 ppt (bluegill sunfish Pond 3) to 0.200 ppt wet weight (bluegill sunfish Pond 5). The largemouth bass fillet samples from Pond 5 were slightly higher than the other fish (0.210 and 0.295 ppt). The slightly higher concentration of dioxin/furans in fish from Pond 5 is consistent with the results from the 2004 data.

With the exception of one bluegill sunfish fillet sample from Pond 2 (63.45 ppt lipid) and one bluegill sunfish fillet sample from Pond 3 (55.99 ppt lipid), lipid-normalized TEQs (i.e., the amount of dioxin, as TEQs, present per amount of fat in the fish whole body or fillet) appear to be consistent for bluegill sunfish in Ponds 2, 3, and 5 (Table 3-6). Largemouth bass lipid-normalized TEQs were also generally consistent between Ponds 3 and 5 (no bass were caught in Pond 2), ranging from 18.91 ppt lipid (whole bass in Pond 5) to 96.43 ppt lipid (largemouth bass fillet in Pond 3).

None of the samples exceeded the screening levels for TEQ, regardless of the treatment of non-detects in the calculation of TEQs. This value, as noted in Table 3-2, is the average concentration from fish collected in North America from areas deemed “background” by USEPA, and does not necessarily indicate that consumption of the fish would result in potential health-threat.

3.5 Hay

Hay samples were collected from Pond 3 Farm, which is located very close to the area of maximum deposition of RRF air emissions, Arthur Johnson Farm, which is located within the deposition area but a little farther north from the maximum deposition area, and from a background location in Lucketts, VA (“background”) outside the influence of deposition from RRF air emissions. All samples were analyzed for dioxin/furans, lipids, and the suite of metals described earlier. One of the two hay samples from Pond 3 Farm was split for duplicate analysis. Dioxin/furan data are presented in wet weight and lipid normalized concentrations for individual congeners and TEQs. Metals data are presented on a wet weight basis only.

3.5.1 Inorganic constituents (metals)

Arsenic and beryllium were not detected in any hay samples (Table 3-7). The detection limit for arsenic ranged from 0.14 – 0.27 ppm and the detection limit for beryllium ranged from 0.01 – 0.02 ppm.

Cadmium was detected at very low levels (0.025 – 0.06 ppm “B” qualified) from all locations, including background. Maximum chromium concentrations in background hay (20.9 ppm) were much greater than the maximum concentration in the hay collected at Pond 3 Farm (1.4 ppm) and Arthur Johnson Farm (1.8 ppm). Nickel concentrations in background hay (1.4 ppm) were also higher than Pond 3 Farm (0.41 ppm) and Arthur Johnson Farm (0.57 ppm). Lead and mercury were both detected at low levels, with no discernable pattern. Lipid concentrations were 1.97 – 2.09% in Pond 3 Farm hay, 1.56 – 1.91% in Arthur Johnson Farm hay, and 0.92% in background hay.

Concentrations of cadmium, chromium, mercury and nickel in hay from all three locations were higher than available screening levels. The concentration of lead in hay from Pond 3 Farm (0.27 ppm) was also higher than the lower screening level for lead, but within the range of available lead screening level (0.24 – 1.68 ppm).

3.5.2 Dioxins/furans

Only one furan congener (1,2,3,7,8,9-HxPCDF) was undetected in all hay samples. Levels of all detected congeners appear to be slightly higher in Arthur Johnson Farm hay than in hay from Pond 3 Farm or the background location. TEQs were calculated using two methods; non-detects equal to zero (ND=0) and non-detects equal to the detection limit (ND=DL). TEQs (ND=0) were also higher in hay from Arthur Johnson Farm (0.377 – 1.830 ppt and 24.19 – 95.80 ppt lipid) than in background hay (0.006 ppt and 0.69 ppt lipid) or Pond 3 Farm hay (0.038 – 0.203 ppt and 1.79 – 10.29 ppt lipid) (Table 3-7). When TEQs were calculated using detection limits to represent non-detects, the same pattern emerged. There is no screening level for dioxin/furans in hay.

3.6 Milk

Milk samples were collected from the Arthur Johnson Farm. All samples were analyzed for dioxin/furans, lipids, and the suite of inorganic constituents described earlier. One of the two milk samples was split for duplicate analysis of metals only. Dioxin/furan data are presented in wet weight and lipid normalized for individual congener concentration and TEQs. Metals data are presented on a wet weight basis only.

3.6.1 Inorganic constituents (metals)

Arsenic, beryllium and mercury were not detected in any milk samples. Detection limits for these metals were 6.9, 0.1 and 0.25 ppb, respectively. Cadmium, chromium, lead and nickel, were detected in milk samples. The maximum concentrations of these metals were 0.15, 139, 3.7 and 5.6 ppb, respectively (Table 3-8). Lipid concentrations were 3.01 – 3.43% in milk samples.

Chromium concentrations in milk exceeded their respective screening level (Table 3-8).

3.6.2 Dioxins/furans

Five of the eight furan congeners (2,3,7,8-TCDF, 1,2,3,7,8-PeCDF, 1,2,3,7,8,9-HxCDF, 1,2,3,4,6,7,8-HpCDF and 1,2,3,4,7,8,9-HpCDF) were not detected in the milk samples. All of the dioxin congeners were detected in the milk samples. TEQs were calculated using two methods; non-detects equal to zero (ND=0) and non-detects equal to the detection limit (ND=DL). Wet weight and lipid-normalized dioxin TEQs are presented in Table 3-8. Maximum TEQs (ND=0) were 67.287 ppq wet weight, and 2,235 ppq lipid. Maximum TEQs (ND=DL) were 69.673 ppq wet weight, and 2315 ppq lipid. None of the lipid-normalized TEQs (ND=0 and ND=DL) in sampled milk exceeded the screening level 3,000 ppq lipid) (Table 3-8).

Table 3-1
Dioxin/Furan Toxic Equivalency Factors

Congener	TEF
2,3,7,8-TCDF	0.1
2,3,7,8-TCDD	1
1,2,3,7,8-PeCDF	0.03
2,3,4,7,8-PeCDF	0.3
1,2,3,7,8-PeCDD	1
1,2,3,4,7,8-HxCDF	0.1
1,2,3,6,7,8-HxCDF	0.1
2,3,4,6,7,8-HxCDF	0.1
1,2,3,7,8,9-HxCDF	0.1
1,2,3,4,7,8-HxCDD	0.1
1,2,3,6,7,8-HxCDD	0.1
1,2,3,7,8,9-HxCDD	0.1
1,2,3,4,6,7,8-HpCDF	0.01
1,2,3,4,7,8,9-HpCDF	0.01
1,2,3,4,6,7,8-HpCDD	0.01
OCDF	0.0003
OCDD	0.0003

Notes:
TEF: Toxic equivalancy factor
TEFs from van den Berg, et.al, 2006
http://toxsci.oxfordjournals.org/cgi/content/abstract/kfl055v1?ijkey=pio0gXG6dghrndD&keytype=ref

Table 3-2
Screening Levels Used for Comparison

	Screening Value																			
	Surface Water																			
	Human Health Criteria for Fish Consumption		Aquatic Life Screening Values								Milk		Hay[d]		Fish		Sediment			
	Federal AWQC	MD TSC	Federal Chronic AWQC						MD TSC								Selected Value	Consensus		USEPA Region 3
			Pond 2		Pond 3		Pond 5											TEC	PEC	
Dioxins/Furans (ppq)																				
TCDD TEQ[c]	0.0051	0.51	--		--		--		--		--		--		590	[h]	850	--	--	850
TCDD TEQ (lipid)											3000	[o]								
Total Recoverable Metals (ppm)																				
Arsenic	0.00014	0.041	0.15		0.15		0.15		0.15	[c]	0.01	[p]	0.0027 - 0.45	[m]	--		9.79	9.79	33	9.8
Beryllium	--	--	--		--		--		--		0.004	[p]	0.0003 - 0.12	[n]	--		--	--	--	--
Cadmium	--	--	0.00029	[a]	0.00016	[a]	0.00013	[a]	0.00025	[b,c]	0.005	[p]	0.009 - 0.09	[e]	--		0.99	0.99	4.98	0.99
Chromium	--	--	0.011	[b]	0.011	[b]	0.011	[b]	0.011	[c]	0.1	[p]	0.006 - 0.06	[f]	--		43.4	43.4	111	43.4
Lead	--	--	0.0035	[a]	0.0013	[a]	0.0008	[a]	0.0025	[c]	0.015	[l,p]	0.24 - 1.68	[e]	--		35.8	35.8	128	35.8
Mercury	--	--	0.00077		0.00077		0.00077		0.00077		0.002	[p]	0.003	[g]	0.3	[i]	0.18	0.18	1.06	0.18
Nickel	4.6	4.6	0.056	[a]	0.029	[a]	0.022	[a]	0.052	[c]	0.05	[j,p]	0.021 - 0.201	[e]	--		22.7	22.7	48.6	22.7
Hardness (mg/L as $CaCO_3$)			108.5		49.45		35.3													
Dissolved Metals (ppm)																				
Arsenic (dissolved)	--	--	0.15		0.15		0.15		0.15	[c]	--		--		--		--	--	--	--
Beryllium (dissolved)	--	--	--		--		--		--								--	--	--	--
Cadmium (dissolved)	--	--	0.00025	[a]	0.00014	[a]	0.00011	[a]	0.00025	[b,c]	--		--		--		--	--	--	--
Chromium (dissolved)	--	--	0.011	[b]	0.011	[b]	0.011	[b]	0.011	[c]	--		--		--		--	--	--	--
Lead (dissolved)	--	--	0.0025	[a]	0.0011	[a]	0.0007	[a]	0.0025	[c]	--		--		--		--	--	--	--
Mercury (dissolved)	--	--	0.00077		0.00077		0.00077		0.00077		--		--		--		--	--	--	--
Nickel (dissolved)	--	--	0.052	[a]	0.027	[a]	0.020	[a]	0.052	[c]	--		--		--		--	--	--	--
Hardness (mg/L as $CaCO_3$)			99.5		46.45		32.7													

ppq = parts per quadrillion; pg/L for liquid, pg/kg for solids
ppm = parts per million; mg/L for liquid, mg/kg for solids
MD TSC = MD Toxic Substances Chronic Level Criteria; 26.08.02.03-2 Numerical Criteria for Toxic Substances in Surface Waters. July 19, 4004
Federal AWQC = Ambient Water Quality Criteria, U.S. EPA (1999). Human Health are for consumption of fish only.
MCL = Maximum Contaminant Level; EPA 816-F-02-013, July 2002
USEPA Region 3 - Freshwater Sediment Screening Benchmarks [http://www.epa.gov/reg3hwmd/risk/eco/btag/sbv/fwsed/screenbench.htm]
[a] Values presented are for total metals and are normalized to site-specific hardness values for each Farm Pond.
[b] Criteria for Chromium VI
[c] Toxicity is dependent on hardness and/or pH. Value presented as cited in MD 26.08.02.03-2 January 26, 2001
[d] Values for hay are common concentrations measured in vegetation from Kabata-Pendias and Pendias, 1984
[e] Value is for immature grasses
[f] Value is for general vegetation
[g] Value is for grasses and feed legumes
[h] TCDD TEQ of 60 fish samples collected in North America as reported in U.S. EPA (1984) Estimating Exposure to Dioxin-Like Compounds
[i] U.S. EPA fish flesh criterion for methyl mercury.
[j] Typical level in cow's milk. Univeristy of Guelph, Canada
[k] Hardness not collected in 2004; value presented is from 2001 event.
[l] Value is the action limit posted in the MCLs.
[m] Plants grown in uncontaminated soil
[n] Plants grown under natural conditions
[o] Value is the European Commission (2002, 2005) Maximum Level for dioxin in milk. Concentrations are lipid-normalized.
[p] Screening levels for milk are USEPA MCLs, which are protective of human exposure to groundwater (as tap water)

Table 3-3
Water Quality Data for Ponds

Location **Depth of measurement**	**Temperature (C)**	**Spec.Cond. uS/cm**	**Dissolved Oxygen**		**pH**
			(%)	**(mg/L)**	
Measurements Taken June 12, 2007					
Pond 2 (water depth: 6 ft)					
Measurement depth: 3 ft	24.4	234	91.7	7.65	8.6
Measurements Taken June 12, 2007					
Pond 3 (water depth: 4 ft)					
Edge of Pond depth: 0.5 ft	23.5	129	60[a]	5.04	8.7
Measurement depth: 2 ft	23.7	134	46	3.99	8.1
Measurements Taken June 13, 2007					
Pond 5 (water depth 1 ft)					
Measurement depth: 0.5 ft	26.6	93	112	8.99	8.8

C = Celsius
uS/cm = micro Siemens per centimeter
mg/L = milligrams per liter; parts per million
[a] Value estimated from temperature and oxygen as mg/L

Table 3-4
Comparison to Screening Benchmarks: Constituents Detected in Surface Water

Lab ID	Screening Levels[a]				Pond 2		Pond 3		Pond 5	
	Human Health Criteria for Fish Consumption		Aquatic Life Screening Values		EFSW02AA 6/12/2007	EFSW01AA 6/12/2007	LFSW01AA 6/12/2007	LFSW02AA[e] 6/12/2007	SLSW01AA 6/13/2007	SLSW02AA 6/13/2007
	Federal AWQC	MD TSC	Federal AWQC[b]	MD TSC						
Dioxins/Furans (ppq)										
2,3,7,8-TCDD	--	--	--	--	0.517 U	0.536 U	0.521 U	0.508 U	0.53 U	0.582 K
1,2,3,4,6,7,8-HpCDD	--	--	--	--	10.9	7.91	3.18	2.68 K	8.43	3.55
OCDD	--	--	--	--	460	396	96.9	90	499	118
2,3,4,7,8-PeCDF	--	--	--	--	0.586	0.536 U	0.521 U	0.508 U	0.53 U	0.541 U
1,2,3,4,6,7,8-HpCDF	--	--	--	--	0.826 K	0.536 U	0.521 U	0.508 U	0.53 U	0.616 K
OCDF	--	--	--	--	1.84	1.04 K	0.74	0.653	1.02	1.1 K
TCDD TEQ[c]	0.0051	0.51	--	--	**1.900**	**1.887**	**1.702**	**1.654**	**1.904**	**1.817**
TCDD TEQ[d]	0.0051	0.51	--	--	**0.432**	**0.198**	**0.061**	**0.054**	**0.234**	**1.895**
Total Metals (ppb)										
Beryllium	--	--	--	--	0.21 B	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Cadmium	--	--	0.13	0.25	0.05 U	0.05 U	0.05 U	0.06 B	0.12 B	0.05 U
Chromium	--	--	11	11	3.1	0.95 U	0.95 U	0.95 U	1 B	0.95 U
Lead	--	--	0.8	2.5	**3.4**	0.52 B	0.31 B	0.32 B	0.3 B	0.15 U
Nickel	4600	4600	22	52	4.5	1.5	2.1	2.4	0.5 B	0.45 B
Hardness (mg/L as $CaCO_3$)					112	105	49.4	49.5	36.8	33.8
Dissolved Metals (ppb)										
Cadmium (dissolved)	--	--	0.11	0.25	0.06 B	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Lead (dissolved)	--	--	0.7	2.5	**1.4**	**4**	**0.77 B**	**1.45**	0.15 U	0.15 U
Nickel (dissolved)	--	--	20	52	1.1	0.92 B	1.8	2.05	0.38 B	0.42 B
Hardness (mg/L as $CaCO_3$)					102	97	46.4	46.5	31.9	33.5

[a] Refer to Table 3-2 for source of screening levels
[b] Certain screening values normalized to site-specific hardness as $CaCO_3$. Only the lowest calculated screening value (Pond 5 screening value; Refer to Table 3-2) is presented for these metals.
[c] TEQs calculated using mamallian TEFs. TEQ calculated assuming nondetect values were equal to the achieved detection limits
[d] TEQs calculated using mamallian TEFs and only detected PCDD/PCDFs. TEQ calculated assuming all nondetect values were zero
[e] Concentration is average of sample and duplicate.
ppq - parts per quadrillion
ppb = parts per billion
mg/L as $CaCO_3$ = milligrams per liter as calcium carbonate
U - compound was analyzed for but not detected above the laboratory Practical Quantitation Limit.
B - The analyte was detected in the sample at a concentration greater than the instrument detection limit, but less than the lab's practical quantitation limit
K = Estimated concentration. Peak detected but did not meet quantification criteria. Number following this flag represents the estimated maximum possible concentration.
Bold text indicates the concentration exceeds one or more screening values.

Table 3-5
Comparison of Data to Screening Benchmarks: Constituents Detected in Sediment

		Pond 2		Pond 3		Pond 5	
Lab ID	**Sediment Screening Level [a]**	**EFSD02AA 6/12/2007**	**EFSD01AA 6/12/2007**	**LFSD01AA 6/12/2007**	**LFSD02AA[e] 6/12/2007**	**SLSD01AA 6/13/2007**	**SLSD02AA 6/13/2007**
Dioxins/Furans (ppt)							
2,3,7,8-TCDD	--	0.0855 K	0.104 K	0.167	0.1925 K	0.206	0.425
1,2,3,7,8-PeCDD	--	0.271	0.379	0.429	0.5315	0.588	0.322
1,2,3,4,7,8-HxCDD	--	0.6685	0.775	0.957	1.365	1.43	0.64
1,2,3,6,7,8-HxCDD	--	1.1235	1.06	1.44	1.995	2	0.975
1,2,3,7,8,9-HxCDD	--	1.455	1.48	2.34	3.295	3.07	1.48
1,2,3,4,6,7,8-HpCDD	--	56.5	45.8	57.5	81.3	87.5	34.7
OCDD	--	2910	3090	2370	3635	6200	1930
2,3,7,8-TCDF	--	0.172	0.228	0.564	0.7295	0.455	0.49
1,2,3,7,8-PeCDF	--	0.067 K	0.095	0.159	0.2075	0.154 K	0.177
2,3,4,7,8-PeCDF	--	0.106 K	0.147	0.22	0.2785	0.247	0.247
1,2,3,4,7,8-HxCDF	--	0.151	0.182	0.232	0.3745	0.307	0.358
1,2,3,6,7,8-HxCDF	--	0.108 K	0.127	0.211	0.3085	0.231	0.232
1,2,3,7,8,9-HxCDF	--	0.03805 U	0.0447 U	0.0393 U	0.0472 U	0.0397 U	0.053 K
2,3,4,6,7,8-HxCDF	--	0.127 K	0.16	0.243	0.3135	0.292	0.332
1,2,3,4,6,7,8-HpCDF	--	1.83	1.06	1.83	2.79	1.78	1.72
1,2,3,4,7,8,9-HpCDF	--	0.1555 K	0.092	0.125 K	0.1795	0.141	0.159
OCDF	--	5.71	2.03	2.97	4.935	3.75	2.45
TCDD TEQ[c]	0.85	**2.234**	**2.333**	**2.576**	**3.591**	**4.411**	**2.228**
TCDD TEQ[d]	0.85	**2.145**	**2.224**	**2.405**	**3.394**	**4.201**	**1.803**
Total Metals (ppm)							
Arsenic	9.79	1.2	2.7	1.2	1.5	1.5	2.6
Beryllium	--	0.74	0.8	0.86	1.05	0.62	0.49
Cadmium	0.99	0.09 B	0.08 B	0.19 B	0.17 B	0.08 B	0.08 B
Chromium	43.4	22.1	21.9	24.3	28.5	19.4	18.6
Lead	35.8	17.1	15.6	15.8	18.1	18	18.9
Mercury	0.18	0.02 B	0.02 B	0.04 B	0.04 B	0.03 B	0.05 B
Nickel	22.7	16.9	16.3	18	20.55	12.1	8.6
Total Organic Carbon	--	16000	16000	41000	43000	70000	67000

[a] Refer to Table 3-2 for source of screening levels
[b] Certain screening values normalized to site-specific TOC. Only the lowest calculated screening value (Pond 3 screening value; Refer to Table 3-2) is presented for these metals.
[c] TEQs calculated using mamallian TEFs. TEQ calculated assuming nondetect values were equal to the achieved detection limits
[d] TEQs calculated using mamallian TEFs and only detected PCDD/PCDFs. TEQ calculated assuming all nondetect values were zero
[e] Concentration is average of sample and duplicate.
ppt = parts per trillion
ppm = parts per million
U - compound was analyzed for but not detected above the laboratory Practical Quantitation Limit.
B - The analyte was detected in the sample at a concentration greater than the instrument detection limit, but less than the lab's practical quantitation limit
K = Estimated concentration. Peak detected but did not meet quantification criteria. Number following this flag represents the estimated maximum possible concentration.
Bold text indicates the concentration exceeds one or more screening values.

Table 3-6
Comparison of Data to Screening Benchmarks: Constituents Detected in Fish Tissue

		Pond 2				Pond 3							
ID	Screening Level [a]	EFBG01AAW	EFBG02AAW	EFBG01AAF	EFBG02AAF	LFBG01AAW	LFBG02AAW	LFBG01AAF	LFBG02AAF	LFLMB01AAW[b]	LFLMB02AAW	LFLMB01AAF[b]	LFLMB02AAF
Tissue Type		Whole	Whole	Fillet	Fillet	Whole	Whole	Fillet	Fillet	Whole	Whole	Fillet	Fillet
Species		Bluegill	Bluegill	Bluegill	Bluegill	Bluegill	Bluegill	Bluegill	Bluegill	LMB	LMB	LMB	LMB
Lab ID		6/12/2007	6/12/2007	6/12/2007	6/12/2007	6/11/2007	6/11-12/2007	6/11/2007	6/11-12/2007	6/11-12/2007	6/11/2007	6/11-12/2007	6/11/2007
Dioxins/Furans (ppt)													
2,3,7,8-TCDD	--	0.193	0.088 K	0.073 K	0.068 K	0.143 K	0.08 K	0.048 K	0.0494 U	0.14 K	0.139 K	0.0516 K	0.085 K
1,2,3,7,8-PeCDD	--	0.058	0.073 K	0.0471 U	0.0502 U	0.093 K	0.057 K	0.0475 U	0.0494 U	0.068 K	0.112	0.0495 U	0.0495 U
1,2,3,4,7,8-HxCDD	--	0.0489 U	0.0494 U	0.0471 U	0.0502 U	0.086 K	0.0487 U	0.0475 U	0.0494 U	0.0585 K	0.048 K	0.0495 U	0.0495 U
1,2,3,6,7,8-HxCDD	--	0.096 K	0.053	0.0471 U	0.0502 U	0.16 K	0.077 K	0.0475 U	0.0494 U	0.0735 K	0.071 K	0.0495 U	0.0495 U
1,2,3,7,8,9-HxCDD	--	0.052 K	0.0494 U	0.0471 U	0.0502 U	0.05 K	0.0487 U	0.0475 U	0.0494 U	0.04975 U	0.069 K	0.0495 U	0.0495 U
1,2,3,4,6,7,8-HpCDD	--	0.476	0.47	0.135 K	0.115	0.49 K	0.328	0.11 K	0.11 K	0.2055 K	0.215 K	0.0575 K	0.07 K
OCDD	--	9.71	13.7	1.36	1.82	5.89	5.18	0.354	0.198	1.34	1.02	0.206	0.267
2,3,7,8-TCDF	--	0.116	0.093	0.0471 U	0.0502 U	0.231	0.121	0.0475 U	0.0494 U	0.1175 K	0.086	0.0495 U	0.056 K
1,2,3,7,8-PeCDF	--	0.0489 U	0.0494 U	0.0471 U	0.0502 U	0.0497 U	0.053 K	0.0475 U	0.0494 U	0.0492 U	0.0471 U	0.0495 U	0.0495 U
2,3,4,7,8-PeCDF	--	0.0489 U	0.0494 U	0.0471 U	0.0502 U	0.067	0.0487 U	0.0475 U	0.0494 U	0.0547 K	0.073 K	0.0511 K	0.0495 U
1,2,3,4,7,8-HxCDF	--	0.0489 U	0.0494 U	0.0471 U	0.0502 U	0.05 K	0.0487 U	0.0475 U	0.0494 U	0.0492 U	0.0471 U	0.0495 U	0.0495 U
2,3,4,6,7,8-HxCDF	--	0.0489 U	0.0494 U	0.0471 U	0.0502 U	0.0497 U	0.0487 U	0.0475 U	0.0494 U	0.0492 U	0.0471 U	0.0495 U	0.0495 U
1,2,3,4,6,7,8-HpCDF	--	0.0489 U	0.0494 U	0.075 K	0.0502 U	0.0497 U	0.0487 U	0.062 K	0.0494 U	0.0492 U	0.0471 U	0.0495 U	0.0495 U
1,2,3,4,7,8,9-HpCDF	--	0.0489 U	0.0494 U	0.051 K	0.0502 U	0.0497 U	0.0487 U	0.0475 U	0.0494 U	0.0492 U	0.0471 U	0.0495 U	0.0495 U
OCDF	--	0.066 K	0.083 K	0.147 K	0.074	0.053	0.0487 U	0.229	0.0494 U	0.086 K	0.061 K	0.0814 K	0.0495 U
Lipid (%)		2.69	2.21		0.28	3.13	1.37	0.46	0.28	1.285	0.69	0.215	0.2
TCDD TEQ[c]	0.59	0.327	0.231	0.176	0.178	0.338	0.208	0.152	0.157	0.279	0.324	0.159	0.193
TCDD TEQ [c] (lipid normalized)	--	12.14	10.47	NC	63.45	10.79	15.19	32.94	55.99	21.71	46.95	74.03	96.43
TCDD TEQ[d]	0.59	0.285	0.184	0.076	0.070	0.320	0.163	0.050	0.0012	0.252	0.303	0.068	0.091
TCDD TEQ [d] (lipid normalized)	--	10.60	8.35	NC	24.90	10.24	11.91	10.85	0.41	19.60	43.88	31.44	45.69
Metals (ppm)													
Arsenic	--	0.14 U	0.12 B	0.11 U	0.13 U	0.12 U	0.11 U	0.14 U	0.12 U	0.1 U	0.13 U	0.14 U	0.12 U
Cadmium	--	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 B	0.01 U	0.01 U
Chromium	--	0.5	0.53	0.3	0.32	0.37	0.2	0.19 B	0.17 B	0.21	0.78	0.26	0.22
Lead	--	0.19	0.21	0.03 B	0.03 B	0.04 B	0.07	0.04 B	0.03 B	0.05 B	0.1	0.03 B	0.03 B
Mercury	0.3	0.05	0.05	0.06	0.07	0.03 B	0.03	0.07	0.08	**0.41**	0.05	**0.47**	0.13
Nickel	--	0.24	0.29	0.05 B	0.06 B	0.13	0.16	0.03 B	0.02 B	0.08	0.36	0.03 U	0.02 B

Note:
LMB = Largemouth bass
-- = No screening value available
NC = Not calculated; lipid data not available
[a] Refer to Table 3-2 for source of screening levels
[b] Concentration is average of sample and duplicate.
[c] TEQs calculated using mamallian TEFs. TEQ calculated assuming nondetect values were equal to the achieved detection limits
[d] TEQs calculated using mamallian TEFs and only detected PCDD/PCDFs. TEQ calculated assuming all nondetect values were zero
ppt = parts per trillion
ppm =; parts per million
U - compound was analyzed for but not detected above the laboratory Practical Quantitation Limit.
B - The analyte was detected in the sample at a concentration greater than the instrument detection limit, but less than the lab's practical quantitation limit
K = Estimated concentration. Peak detected but did not meet quantification criteria. Number following this flag represents the estimated maximum possible concentration.
Bold text indicates the concentration exceeds one or more screening values.

Table 3-6 (con't)
Comparison of Data to Screening Benchmarks: Constituents Detected in Fish Tissue

		Pond 5							
ID **Tissue Type** **Species** **Lab ID**	**Screening Level [a]**	**SLBG01AAW** **Whole** **Bluegill** **6/13/2007**	**SLBG02AAW** **Whole** **Bluegill** **6/13/2007**	**SLBG01AAF[b]** **Fillet** **Bluegill** **6/13/2007**	**SLBG02AAF** **Fillet** **Bluegill** **6/13/2007**	**SLLMB01AAW** **Whole** **LMB** **6/13/2007**	**SLLMB02AAW** **Whole** **LMB** **6/13/2007**	**SLLMB01AAF** **Fillet** **LMB** **6/13/2007**	**SLLMB02AAF** **Fillet** **LMB** **6/13/2007**
Dioxins/Furans (ppt)									
2,3,7,8-TCDD	--	0.347	0.379	0.095 K	0.085 K	0.387	0.416	0.183	0.099 K
1,2,3,7,8-PeCDD	--	0.049 K	0.062 K	0.0481 U	0.0477 U	0.106	0.053	0.053 K	0.0493 U
1,2,3,4,7,8-HxCDD	--	0.0477 U	0.05 U	0.0481 U	0.0477 U	0.0484 U	0.065	0.05 U	0.053 K
1,2,3,6,7,8-HxCDD	--	0.098	0.079	0.0481 U	0.0477 U	0.088	0.077 K	0.05 U	0.0493 U
1,2,3,7,8,9-HxCDD	--	0.057 K	0.05 U	0.0481 U	0.0477 U	0.0484 U	0.083 K	0.05 U	0.0493 U
1,2,3,4,6,7,8-HpCDD	--	0.326	0.408	0.097 K	0.061 K	0.252	0.279	0.079 K	0.102
OCDD	--	7.77	10.6	0.766	0.331 K	3.43	3.3	0.533	0.438 K
2,3,7,8-TCDF	--	0.147	0.184	0.0481 U	0.0477 U	0.1	0.174	0.056 K	0.0493 U
1,2,3,7,8-PeCDF	--	0.0477 U	0.05 U	0.0481 U	0.0477 U	0.0484 U	0.0495 U	0.05 U	0.0493 U
2,3,4,7,8-PeCDF	--	0.06	0.05 U	0.0481 U	0.0477 U	0.064	0.076 K	0.05 U	0.056 K
1,2,3,4,7,8-HxCDF	--	0.0477 U	0.05 U	0.0481 U	0.0477 U	0.0484 U	0.0495 U	0.05 U	0.061 K
2,3,4,6,7,8-HxCDF	--	0.0477 U	0.05 U	0.0481 U	0.0477 U	0.0484 U	0.0495 U	0.05 U	0.052 K
1,2,3,4,6,7,8-HpCDF	--	0.0477 U	0.05 U	0.0481 U	0.0477 U	0.072 K	0.051 K	0.055 K	0.07 K
1,2,3,4,7,8,9-HpCDF	--	0.0477 U	0.05 U	0.0481 U	0.0477 U	0.0484 U	0.0495 U	0.05 U	0.0493 U
OCDF	--	0.062 K	0.05 U	0.065 K	0.118	0.062	0.078 K	0.075 K	0.17 K
Lipid (%)		2.34	3.66			1.44	2.95	0.35	
TCDD TEQ[c]	0.59	0.476	0.522	0.200	0.188	0.566	0.558	0.295	0.210
TCDD TEQ [c] (lipid normalized)	--	20.34	14.26	NC	NC	39.32	18.91	84.32	NC
TCDD TEQ[d]	0.59	0.450	0.475	0.096	0.086	0.535	0.536	0.243	0.134
TCDD TEQ [d] (lipid normalized)	--	19.22	12.97	NC	NC	37.17	18.17	69.46	NC
Metals (ppm)									
Arsenic	--	0.11 U	0.11 U	0.12 U	0.1 U	0.11 U	0.09 U	0.13 U	0.1 U
Cadmium	--	0.01 U	0.01 U	0.01 U	0.01 U	0.01 B	0.03 B	0.01 U	0.01 U
Chromium	--	0.235 B	0.18 B	0.21 B	0.2	0.26	0.14 B	0.27	0.22
Lead	--	0.065 B	0.07	0.045 B	0.02 U	0.23	0.07	0.03 B	0.02 U
Mercury	0.3	0.07	0.08	0.13	0.11	0.25	0.29	**0.49**	**0.5**
Nickel	--	0.1	0.1	0.03 B	0.03 B	0.16	0.03 B	0.03 U	0.02 U

Note:
LMB = Largemouth bass
-- = No screening value available
NC = Not calculated; lipid data not available
[a] Refer to Table 3-2 for source of screening levels
[b] Concentration is average of sample and duplicate.
[c] TEQs calculated using mamallian TEFs. TEQ calculated assuming nondetect values were equal to the achieved detection limits
[d] TEQs calculated using mamallian TEFs and only detected PCDD/PCDFs. TEQ calculated assuming all nondetect values were zero
ppt = parts per trillion
ppm =; parts per million
U - compound was analyzed for but not detected above the laboratory Practical Quantitation Limit.
B - The analyte was detected in the sample at a concentration greater than the instrument detection limit, but less than the lab's practical quantitation limit
K = Estimated concentration. Peak detected but did not meet quantification criteria. Number following this flag represents the estimated maximum possible concentration.
Bold text indicates the concentration exceeds one or more screening values.

Table 3-7
Comparison of Data to Screening Benchmarks: Constituents Detected in Hay

ID	Screening	Background	Lermond Farm		Arthur Johnson Farm	
		RHH01AA	LFH01AA-R[d]	LFH02AA-R	AJH01AA	AJH02AA
Lab ID	Level [a]	6/11/2007	6/12/2007	6/12/2007	6/11/2007	6/11/2007
Dioxins/Furans (ppt)						
2,3,7,8-TCDD	--	0.0449 U	0.05 U	0.0489 U	0.055 K	0.096 K
1,2,3,7,8-PeCDD	--	0.0449 U	0.05 U	0.076	0.102 K	0.577
1,2,3,4,7,8-HxCDD	--	0.0449 U	0.05 U	0.055	0.192	0.992
1,2,3,6,7,8-HxCDD	--	0.0449 U	0.05 U	0.098	0.237 K	1.38
1,2,3,7,8,9-HxCDD	--	0.0449 U	0.05 U	0.254 K	0.459	3.01
1,2,3,4,6,7,8-HpCDD	--	0.383	0.602	3.53	5.11	31.9
OCDD	--	3.73	6.61	83	46	319
2,3,7,8-TCDF	--	0.0449 U	0.058	0.052 K	0.09	0.129
1,2,3,7,8-PeCDF	--	0.0449 U	0.05 U	0.0489 U	0.0496 U	0.05
2,3,4,7,8-PeCDF	--	0.0449 U	0.065 K	0.051	0.052 K	0.085
1,2,3,4,7,8-HxCDF	--	0.0449 U	0.05 U	0.0489 U	0.117 K	0.252
1,2,3,6,7,8-HxCDF	--	0.0449 U	0.05 U	0.0489 U	0.08 K	0.332
2,3,4,6,7,8-HxCDF	--	0.0449 U	0.05 U	0.0489 U	0.072 K	0.356
1,2,3,4,6,7,8-HpCDF	--	0.125	0.353	0.476	1.36	6.53
1,2,3,4,7,8,9-HpCDF	--	0.0449 U	0.05 U	0.0489 U	0.094	0.188
OCDF	--	0.427	2.25	1.56	2.31	9.18
TCDD TEQ[b]	--	0.147	0.175	0.273	0.384	1.834
TCDD TEQ [b] (lipid normalized)	--	16.01	8.35	13.86	24.61	96.03
TCDD TEQ[c]	--	0.006	0.038	0.203	0.377	1.830
TCDD TEQ [c] (lipid normalized)	--	0.69	1.79	10.29	24.19	95.80
Metals (ppm)						
Cadmium	0.009 - 0.09	**0.04 B**	**0.025 B**	**0.03 B**	**0.06 B**	**0.01 U**
Chromium	0.006 - 0.06	**20.9**	**0.81**	**1.4**	**1.8**	**0.74**
Lead	0.24 - 1.68	0.15 B	0.235	**0.27**	0.16	0.06 B
Mercury	0.003	**0.01 U**	**0.015 B**	**0.01 U**	**0.02 B**	**0.01 U**
Nickel	0.021 - 0.201	**1.4**	**0.39**	**0.41**	**0.57**	**0.25**
Lipid (%)		0.92	2.09	1.97	1.56	1.91

Note:

-- = not analyzed
[a] Refer to Table 3-2 for source of screening levels
[b] TEQs calculated using mamallian TEFs. TEQ calculated assuming nondetect values were equal to the achieved detection limits
[c] TEQs calculated using mamallian TEFs and only detected PCDD/PCDFs. TEQ calculated assuming all nondetect values were zero
[d] Concentration is average of sample and duplicate.
ppt = parts per trillion
ppm = parts per million
U - compound was analyzed for but not detected above the laboratory Practical Quantitation Limi, sample-specific detection limit achieved by the laboratory from that time
B - The analyte was detected in the sample at a concentration greater than the instrument detection limit, but less than the lab's practical quantitation limit
K = Estimated concentration. Peak detected but did not meet quantification criteria. Number following this flag represents the estimated maximum possible concentration.
Bold text indicates the concentration exceeds one or more screening values.

Table 3-8
Comparison of Data to Screening Benchmarks: Constituents Detected in Milk

ID Lab ID	Screening Level [a]	AJM01AA 6/11/2007		AJM02AA/AB[b] 6/11/2007	
Dioxins/Furans (ppq)					
2,3,7,8-TCDD	--	10.4	K	12.05	K
1,2,3,7,8-PeCDD	--	30.1		25.25	K
1,2,3,4,7,8-HxCDD	--	31		29.6	K
1,2,3,6,7,8-HxCDD	--	91		75.65	K
1,2,3,7,8,9-HxCDD	--	39.2		45.4	K
1,2,3,4,6,7,8-HpCDD	--	261		235	
OCDD	--	363		339	
2,3,4,7,8-PeCDF	--	13.9		13.05	
1,2,3,4,7,8-HxCDF	--	11.1		9.945	U
1,2,3,6,7,8-HxCDF	--	11.3		11.195	K
2,3,4,6,7,8-HxCDF	--	12.4	K	11.29	K
1,2,3,4,6,7,8-HpCDF	--	29.8		34.25	
TCDD TEQ[c]	--	69.673		64.707	
TCDD TEQ [c] (lipid normalized)	3000	2315		1887	
TCDD TEQ[d]	--	67.287		61.323	
TCDD TEQ [d] (lipid normalized)	3000	2235		1788	
Metals (ppb)					
Cadmium	5	0.15	B	0.255	B
Chromium	100	**139**		**129.5**	
Lead	15	3.7		3.4	
Nickel	50	5.6		5.4	
Lipid (%)		3.01		3.43	

[a] Refer to Table 3-2 for source of screening levels
[b] Concentration is average of sample and duplicate.
[c] TEQs calculated using mamallian TEFs. TEQ calculated assuming nondetect values
were equal to the achieved detection limits
[d] TEQs calculated using mamallian TEFs and only detected PCDD/PCDFs. TEQ calculated
calculated assuming all nondetect values were zero
ppq = parts per quadrillion
ppb = parts per billion
U - compound was analyzed for but not detected above the laboratory Practical Quantitation Limit.
Bold text indicates the concentration exceeds one or more screening values.
K = Estimated concentration. Peak detected but did not meet quantification criteria.
Number following this flag represents the estimated maximum possible concentration.

4.0 Data analysis

The following subsections evaluate the results of the calendar year 2007 chemical analyses relative to data obtained in prior sampling events. Data from the 1994, 1996, and 1998 sampling events were obtained from Weston (2000). Data from 2001 and 2004 were obtained from ENSR (2002, 2006). Table 2-2, Appendix B, and Section 2 describe the method detection limits that have been achieved in each of the sampling programs. It must be noted that lower detection limits were achieved beginning in the calendar year 2001 program. As such, inorganic compounds not previously detected in non-air media were detected in 2001 through 2007. This does not imply that levels of these compounds have increased; rather that the analytical program has been upgraded to provide higher resolution data with lower analytical detection limits. Lower detection limits were achieved in 2001, 2004 and 2007 due to improved sample preparation methods (to minimize matrix interferences) and better laboratory instrumentation. This higher resolution enhances the possibility of detecting trends when concentrations are very low. For added information, each graph in this Section 4 notes the related “screening level” value identified in Section 3. Only constituents detected in 2007 samples are presented in the graphs in Section 4.

4.1 Inorganic constituents (metals)

Inorganic compounds selected for monitoring in the non-air media program included arsenic, beryllium, cadmium, chromium, lead, mercury, and nickel. The RRF has U.S. EPA or Maryland State permit limits for emissions of lead, cadmium, mercury and beryllium. Figure 4-1 presents the metals fingerprint for stack emissions from the RRF as determined over the course of quarterly testing. Mercury is known to be emitted partially in a gaseous state, but the other metals will be predominantly associated with particulates and therefore be expected to be found in wet and dry deposition in the same relative amounts as in the emissions. As illustrated by this graph, emission rates of nickel, chromium, and lead emissions are 2 to 6 times higher than the emission rates of arsenic and cadmium and 10 to 20 times higher than beryllium. Mercury emissions, the highest of the metals, are nearly 7 times higher than lead emissions which are the next highest. It would be expected that potential impacts from the RRF in abiotic environmental media would parallel this fingerprint; that is, deposition should result in relatively higher levels of mercury, nickel, chromium and lead, and relatively lower levels of beryllium, arsenic, or cadmium in abiotic media. It is also noted that of these metals mercury is the most bioaccumulative, and if emissions from the RRF were impacting the surrounding area, mercury would therefore be expected to increase in biotic media (i.e., hay, milk, and fish) at a rate faster than other metals.

4.1.1 Surface water

Pond 2 and Pond 3 were sampled for metals during each of the five monitoring events. As illustrated in Figures 4-2 and 4-3, the detected total recoverable metals concentrations were consistent with, or lower than, concentrations from previous sampling events with the exception of Pond 2 lead and nickel concentrations which were slightly higher in 2007 compared to 2004 but were consistent with or lower than previous years. Pond 5 was sampled for metals in 1994, 1996, 2004 and 2007. Figure 4-4 indicates that Pond 5 surface water metals concentrations are comparable or lower in 2007 compared to 2004.

4.1.2 Sediment

Sediment was sampled from the farm ponds in 2007 for the first time since 1996. The sediment inorganic data from the three farm ponds during 2007 are presented in Figures 4-5 through 4-7. Inorganic constituents in sediment have generally been detected in all sampling events. While it is difficult to conduct trend analysis due to the time gap, the comparison of the 2007 data to the historical data suggest the following.

In Pond 2 (Figure 4-5), concentrations of arsenic, beryllium, and mercury are comparable or lower than historic data collected in previous programs conducted in 1994 and 1996. Cadmium concentrations measured in 2007 are lower than in 1996, but comparable to 1994. Chromium, lead and nickel concentrations in 2007 are slightly higher than historic data collected in 1994 and 1996.

In Pond 3 (Figure 4-6), concentrations of arsenic and cadmium are comparable to or lower than historic data collected in 1994 and 1996. Mercury concentrations are slightly higher than 1996 (first operational) data but lower than the 1994 (pre-operational) data. Beryllium, chromium, lead and nickel concentrations measured in 2007 are slightly higher than historic data collected in 1994 and 1995.

In Pond 5 (Figure 4-7), concentrations of arsenic, beryllium, cadmium and mercury are comparable or lower than historic data collected in 1994 and 1996. Chromium, lead and nickel concentrations measured in 2007 are slightly higher or comparable to historic data collected in 1994 and 1996.

4.1.3 Fish

The fish tissue inorganic data from the three farm ponds during 2007 are presented in Figures 4-8 through 4-12.

In Pond 2, concentrations of metals in whole body and fillet bluegill sunfish are generally comparable or lower than the concentrations detected in previous sampling events (Figure 4-8). It is noted that arsenic, lead and nickel whole body concentrations in 2007 were somewhat higher in 2007 than 2004, but are comparable to or lower than the historic data collected in previous monitoring programs and therefore do not represent an increasing trend. In Pond 2, whole body largemouth bass were not sampled in 1994, and no bass samples were collected in 1996, 2004 or 2007. Therefore, no charts for largemouth bass are presented.

In Pond 3, concentrations of metals in whole body and fillet bluegill sunfish (Figure 4-9) and largemouth bass (Figure 4-10) are generally consistent with, or lower than, concentrations detected in previous sampling events. In 2004, chromium concentrations for whole body bluegill sunfish were slightly higher compared to 2001, but levels in 2007 returned to previous low levels. This highlights the variability found in natural systems, including other media.

In Pond 5, concentrations of metals in fillet and whole bluegill sunfish (Figure 4-11) and fillet and whole body largemouth bass (Figure 4-12) are generally consistent with, or lower than, concentrations detected in previous sampling events with the exception of arsenic in bluegill sunfish fillet, which is only slightly higher than the 2004 data but lower than the 1994 and 1996 data.

4.1.4 Hay

As discussed in Section 2, hay was first collected from Pond 3 Farm beginning in 2001. Concentrations of metals in hay collected in 2007 from Pond 3 Farm are consistent with concentrations detected in previous sampling events for Pond 3 Farm and Kingsbury Dairy Farm (Figure 4-13).

Hay has been collected at Arthur Johnson Farm for two years (2004 and 2007). The metals data for Arthur Johnson Farm, presented on the charts in Figure 4-13, indicate that the 2007 data are comparable or lower than 2004 data. In addition, it is noteworthy that concentrations from hay from Arthur Johnson Farm are consistent with concentrations in hay from Kingsbury Dairy Farm and the Pond 3 Farm.

Chromium and nickel concentrations in hay from the background location in Lucketts, Virginia appear to be higher in 2007 than in previous sampling events and have increased consistently since 2001. This trend was not exhibited at either the Pond 3 Farm or Arthur Johnson Farm. This indicates that sources other than the RRF are contributing these metals to this environment.

4.1.5 Milk

As discussed in Section 2, milk was collected from a new location starting in 2001. In 2001, the Arthur Johnson Farm was selected for sampling because it is the closest existing dairy farm in the deposition area of RRF air emissions. As depicted in Figure 4-14, concentrations of metals in milk from 2007 are consistent with, or lower than, historic metals concentrations from previous monitoring programs.

4.2 Dioxins/furans

Figure 4-15 presents the profile for the pattern of tetra- through octa-chlorinated PCDDs/PCDFs homologues as emitted from the RRF stack based on all actual emissions testing conducted from 1995 through 2007. The dominant homologues include OCDD, OCDF, HpCDD, HpCDF, and HxCDF. As shown in the figure, higher PCDD and PCDF concentrations correspond with higher homologue chlorine content.

Sampling in environmental media for PCDDs/PCDFs was conducted as listed in Table 1-2. Laboratory analyses were conducted for the 1994 pre-operational and 1996 operational phase samples at the same laboratory. The 1998 operational phase samples were analyzed at a different laboratory, which achieved lower detection limits in most media. The laboratories used in 2001 and 2004 achieved lower limits than were achieved in 1998. The same laboratory (Axys Analytical) was used in 2007 as in 2001 and 2004, but detection limits for all media except surface water (where they were similar to 2001 and 2004 data) are an order of magnitude, or more, lower than the detection limits achieved in 2001 and 2004 (Table 2-2). Since detection limits are much lower in 2007, more congeners were detected. It is necessary to recognize the effects of these changes in detection limits, in a meaningful way, as they influence direct comparison of results (as TEQs) over time.

Undetected congeners are a source of considerable uncertainty; the undetected congener may exist at any level between zero and its laboratory detection limit. When interpreting the results, the actual concentration of the congener may be assumed to be zero, or it may be assumed to exist at the detection limit. In the appendix tables of this report, when reporting instances of undetected congeners, the sample-specific numerical detection limit achieved by the laboratory is given and the symbol “U” appears.

In the calculation of a TEQ, the congener-specific uncertainty discussed above is compounded by combining (summing) laboratory results for all seventeen congeners—any number of which may be non-detects. Other than stating the assumptions used, there is no “standard” way to handle non-detects in the calculation of TEQ values. When combining the congener values to calculate a TEQ, one may assume the zero value for all non-detected congeners, or one may assume that the non-detected congeners are present at their sample-specific laboratory detection limits. There are pros and cons. When using only the ***detected*** congeners, the undetected congeners having been assumed to be zero, the TEQ reported in this way is potentially underestimated. If, on the other hand, the analyst assumes that the non-detected congeners are present, not at zero but at their respective detection limits, then the reported TEQ is at risk of being overestimated. Neither assumption has claim to a basis of being more reflective of the actual condition of the environment than the other. Simply stated, the truth lies somewhere in between, and this is most important when the purpose of analysis is to detect trends over time periods during which laboratory detection limits have improved.

Laboratory detection limits have been improving since the first non-air media monitoring in 1994-1995. Figure 4-16 illustrates, for example, how the range of achieved detection limits have changed during this period for the 2,3,7,8-TCDD congener in surface water. With improvement of detection limits (i.e., to lower concentrations), more congeners are being detected now (2007), and fewer congeners are going undetected. Since the actual TEQ values lie somewhere in between those calculated assuming zero for non-detects, and those calculated assuming that the congeners are present at their detection limits, those changes in detection limits, over time, must be taken into account in order to make meaningful any time-series presentation of TEQ results. Therefore, in this report, all time-series presentations of TEQs are presented in paired graphs reflecting both assumptions. In this way, the otherwise confounding role in uncertainty played by changing laboratory detection limits is isolated. The general effect of improved (i.e., lower) laboratory detection limits over time is, of course, a reduction in the uncertainty of monitored values over time. Isolating that source of uncertainty allows more accurate interpretations to be made regarding actual changes in sampled environmental media.

4.2.1 Surface water

When assuming zero values for all non-detects, the calendar year 2007 dioxin concentrations in surface water from all three ponds, represented as TCDD TEQs, were comparable or lower than concentrations in surface water from previous sampling events (Figure 4-17). If detection limits are included, then the 2007 TEQ values are lower than previous years in all ponds, and there may be a declining trend. Regardless of the treatment of non-detects, there is no evidence of any upward trend. As described by ENSR (2002), PCDDs/PCDFs were generally undetected in surface water from previous sampling events. Surface water samples from 1994 and 1996 contained only trace levels of higher chlorinated PCDDs/PCDFs. Consistent with previous samples, surface water collected in 2007 was dominated by the congeners with the highest number of chloride atoms, particularly OCDD (Figure 4-18). The PCDD/PCDF are likely associated with particles suspended in the water column rather than being present as the dissolved fraction of PCDD/PCDFs, which is the fraction most expected to be bioaccumulative.

4.2.2 Sediment

Sediment was sampled from the farm ponds in 2007 for the first time since 1996; there have been only three sediment sampling periods—1994, 1996 and 2007—making any trend analysis difficult. As with other non-aqueous dioxin/furan data, detection limits in the early program data from the 1990's were much higher than in 2007—more congeners are included in the 2007 TEQ. As shown in Figure 4-19, when assuming zero value for all non-detected congeners, the TEQ sediment concentrations appear slightly higher in 2007 than in previous years, however, when detection limits are included, the 2007 TEQ concentrations are either consistent with or lower than previous years. This is the case for all three ponds.

Consistent with surface water, sediment collected in 2007 was dominated by the congeners with the highest number of chloride atoms, particularly OCDD (Figure 4-20).

4.2.3 Fish tissue

TEQ figures presented in this section illustrate the lipid-normalized concentrations only. Lipid-normalized concentrations are relevant for trend analysis because dioxins/furans accumulate in fatty tissues.

Pond 2 fish tissue data for bluegill sunfish are presented in Figure 4-21. Bluegill sunfish samples were not obtained from Pond 2 during the 2004 monitoring period. When assuming zero for all non-detects, the TEQs are slightly higher in 2007 than in previous years ('94, '96, and '01). However, when including detection limits, the TEQs for 2007 are lower than previous years. This pattern is similar to the surface water and sediment results.

In general, the pattern of concentrations of individual congeners detected 2007 are also similar among fish tissue, surface water and sediment. PCCDs/PCDFs in fish tissue from Pond 2 (Figure 4-22) is similar to that detected in Pond 2 surface water (Figure 4-18) and in sediment samples (Figure 4-20). The congener concentrations are dominated by OCDD and followed by some HpCDD—both higher-chlorinated dioxin congeners. The detected lower chlorinated dioxin congeners (including tetra-, penta-, and hexa-CDD) were detected at very low concentrations.

Pond 3 bluegill sunfish and largemouth bass fish tissue data are presented in Figure 4-23. When assuming zero for all non-detects, TEQ concentrations in fish, particularly bass, are higher than the data collected in previous years. However, when detection limits are included, the 2007 TEQs are generally consistent with or lower than the previous years. These results are not inconsistent with those for surface water and sediment.

The pattern of PCCDs/PCDFs in fish tissue from Pond 3 (Figure 4-24) is generally similar to that in Pond 3 surface water (Figure 4-18) and sediment (Figure 4-20). The relative congener concentration patterns are dominated by OCDD and HpCDD, the higher chlorinated dioxin congeners. The lower chlorinated dioxin and furan congeners (including tetra- and penta-CDD/F) were detected in very low concentrations in fish from Pond 3. Since these congeners are more bioaccumulative than the higher chlorinated congeners, this pattern of congener accumulation in tissue is expected.

Pond 5 bluegill sunfish and largemouth bass tissue data are presented in Figure 4-25. Minimal historical bluegill sunfish data from previous monitoring programs are available for Pond 5. Lipid normalized bluegill sunfish fillet data were available only for one monitoring program year (2004), thus, no comparison can be made for that media. In the case of whole body bluegill sunfish, when assuming zero for all non-detects, the TEQ for 2007 was lower than that for 2004 but higher than the 1994 and 1996 values. However, when including the detection limits, the values for 2007 were lower than all previous monitoring periods. Concentrations in whole body samples for bluegill are lower in 2007 compared to 2004. Largemouth bass fillet samples were obtained in three of four monitoring program years (all but pre-operational 1994) and whole body largemouth bass samples were obtained for all four monitoring program periods. In the case of largemouth bass fillet samples, when assuming zero for non-detected congeners for all years, the TEQ calculations for 2007 were slightly higher than for the two previous program monitoring years. However, when including the detection limits, the 2007 TEQ values are slightly higher than the 2004 values, but substantially lower than in 1996. In the case of whole body largemouth bass, when assuming zero for non-detects, the 2007 TEQ values are consistent with prior years, but when including the detection limits, the 2007 TEQ values are either consistent with or lower than previous years. The screening value selected in Section 3 of this report for dioxins TEQ in fish tissue (590 ppq) is not plotted in Figure 4-25 because the value is wet weight, and not lipid-normalized. The pattern of PCCDs/PCDFs in fish tissue from Pond 5 (Figure 4-26) is generally similar to those in the Pond 5 surface water (Figure 4-18) and sediment (Figure 4-20). The concentrations are dominated by OCDD and HpCDD, the higher chlorinated dioxin congeners. Part-per-trillion levels of TCDD are present in both fish and water.

Available data in the literature on bioaccumulation of PCDDs/PCDFs in fish demonstrate that TCDDs, TCDFs, and PeCDFs bioaccumulate at significantly higher rates than higher-chlorinated PCDDs/PCDFs with 6 or more chloride atoms (Opperhuizen and Sum, 1990). As part of EPA's National Bioaccumulation Study (U.S. EPA, 1992) conducted from 1986-89, fish of several species were sampled from a wide variety of sites across the United States. Data for fish from the 34 sites believed to be relatively free of influence from sources were summarized as background; concentration ranges of 0.06 – 2.26 parts per trillion (ppt) 2,3,7,8-TCDD and 0.1-13.7 ppt 2,3,7,8-TCDF were noted in these background samples. All of the detected 2,3,7,8 TCDD concentrations in the monitoring programs fall within the middle of this range (i.e., the maximum detected 2,3,7,8 TCDD concentration is 0.416 ppt).

4.2.4 Hay

Studies reported in the literature (Fries and Paustenbach, 1990) document that, with few exceptions, uptake of PCDDs/PCDFs into plants is not a route for significant human exposure. Deposition onto forage and then uptake by cattle, resulting in bioaccumulation in beef products and milk is predicted to be a more important route of human exposure than direct human consumption of vegetables.

No lipid data were available for hay samples from analysis conducted before 2001. Therefore, data were not normalized to lipid content for this comparison. Figure 4-27, presents the wet weight TEQ concentrations in hay collected in all monitoring periods. In the case of the Kingsbury Farm which is no longer a dairy, post operational phase TEQ values were either consistent with or lower than pre-operational monitoring, and this is true regardless of whether or not detection limits were included in the calculation of TEQ. In the case of the Pond 3 Farm, when assuming that non-detects are zero, the 2007 TEQ is slightly higher than the 2004 result but consistent with or lower than the 2001 result. However, when including non-detects, the 2007 TEQs for hay at this farm are lower than the 2004 results and substantially lower than the 2001 results. In the case of the Arthur Johnson Farm, which was sampled only in the 2004 and 2007 programs, regardless of the treatment of non-detects, the 2007 TEQ values are higher in the 2007 program than in 2004. However no trend is indicated by these two points, or by consideration of hay data from other farms. With respect to the three farms for which hay samples were obtained in three program monitoring periods (Kingsbury '94, '96, '98; Pond 3 Farm '01, '04, '07; and Background '01, '04, '07), TEQ values for succeeding years tend to be either consistent with or lower than prior years and this is the case regardless of the treatment of non-detects.

The PCDDs/PCDFs detected in hay in this study at Pond 3 Farm were predominantly HpCDDs and OCDD, with some HpCDFs and OCDFs (Figure 4-28a), which are the least toxic of the dioxin/furan congeners. Samples from Arthur Johnson Farm and the background location were also dominated by the higher chlorinated congeners, particularly OCDD. Hay samples collected previously from Kingsbury Dairy Farm (Figure 4-28b) also contained predominantly HpCDDs and OCDDs and a variety of tetra- through octa-chlorinated PCDDs/PCDFs at very low levels.

4.2.5 Milk

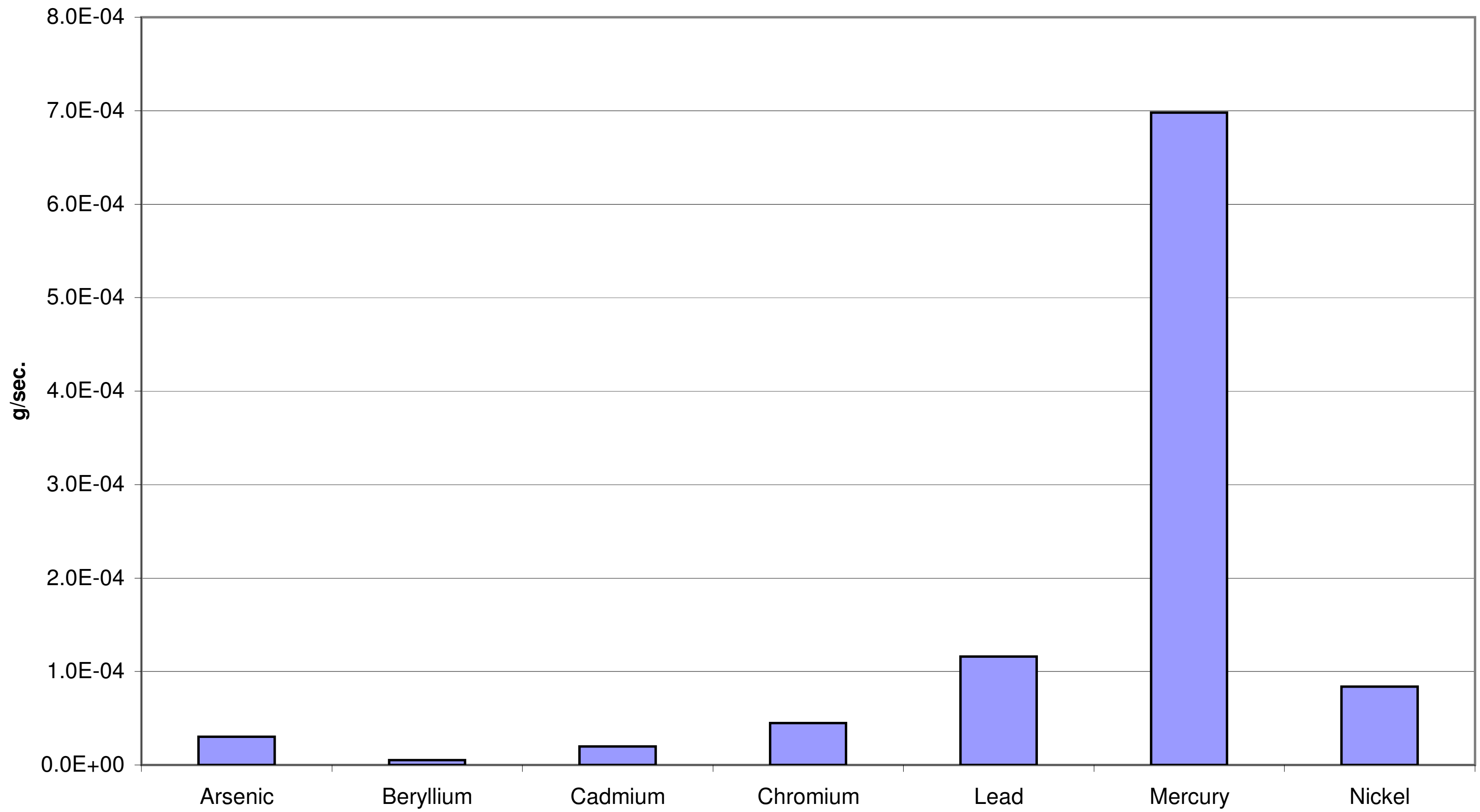
Uptake of PCDDs/PCDFs by cattle from forage or soil with surface contamination has been identified as an important route for human exposure. The source of PCDDs/PCDFs in milk is often unknown, but can be linked to point sources in some cases. One study in 1990 (U.S. EPA, 1990) collected milk samples from several sites in the vicinity of a municipal waste facility in Vermont and from a background location. That study found that only OCDD was consistently found in the farms near the facility and that facility emissions did not correlate with the levels of PCDDs/PCDFs in various environmental media. In another study (Eitzer, 1995), no increase in PCDD/PCDF levels in milk were found following the start up of a municipal waste incinerator. Other studies from Europe (Schmid, et al., 2003 and Ramos et al., 1997) showed higher concentrations of PCDDs/PCDFs in milk samples collected near incinerators or other potential point sources. None of these studies, however, definitively linked PCDDs/PCDFs in cow's milk to the point sources.

Pre-operational and operational phase data sets for the milk sampling program are not directly comparable with respect to TEQ values. This is a result of analytical improvements and significant lowering of detection limits over the program course as discussed in the introduction to this section. Detection limits for milk were approximately 10 times higher for individual toxic PCDDs/PCDFs in 1994 and 1996 than those for the 1998, 2001 and 2004 samples. Detection limits in 2007 were even lower than in previous sampling events (Table 2-2), compounding the concern with calculated TEQ concentrations. Also, due to the discontinuing of dairy operations at the Kingsbury farm after 1998, the sampling location had to be moved to another dairy farm. It should be noted, also, that potential influences on TEQ in sampled milk, such as animal feed and changes in animal feed (other than hay) and changes in animal census, were beyond the scope of the study.

As reflected in Figure 4-29, assuming zero values for all non-detected congeners would yield an apparent increase in monitored lipid-normalized TEQ, however the reverse is true when including the detection limits in the calculation of TEQs. While there is no discernable trend in this respect, the consistency of the lipid-normalized TEQ values for 2007, calculated with and without detection limits, reflects the higher degree to which congeners are now able to be detected.

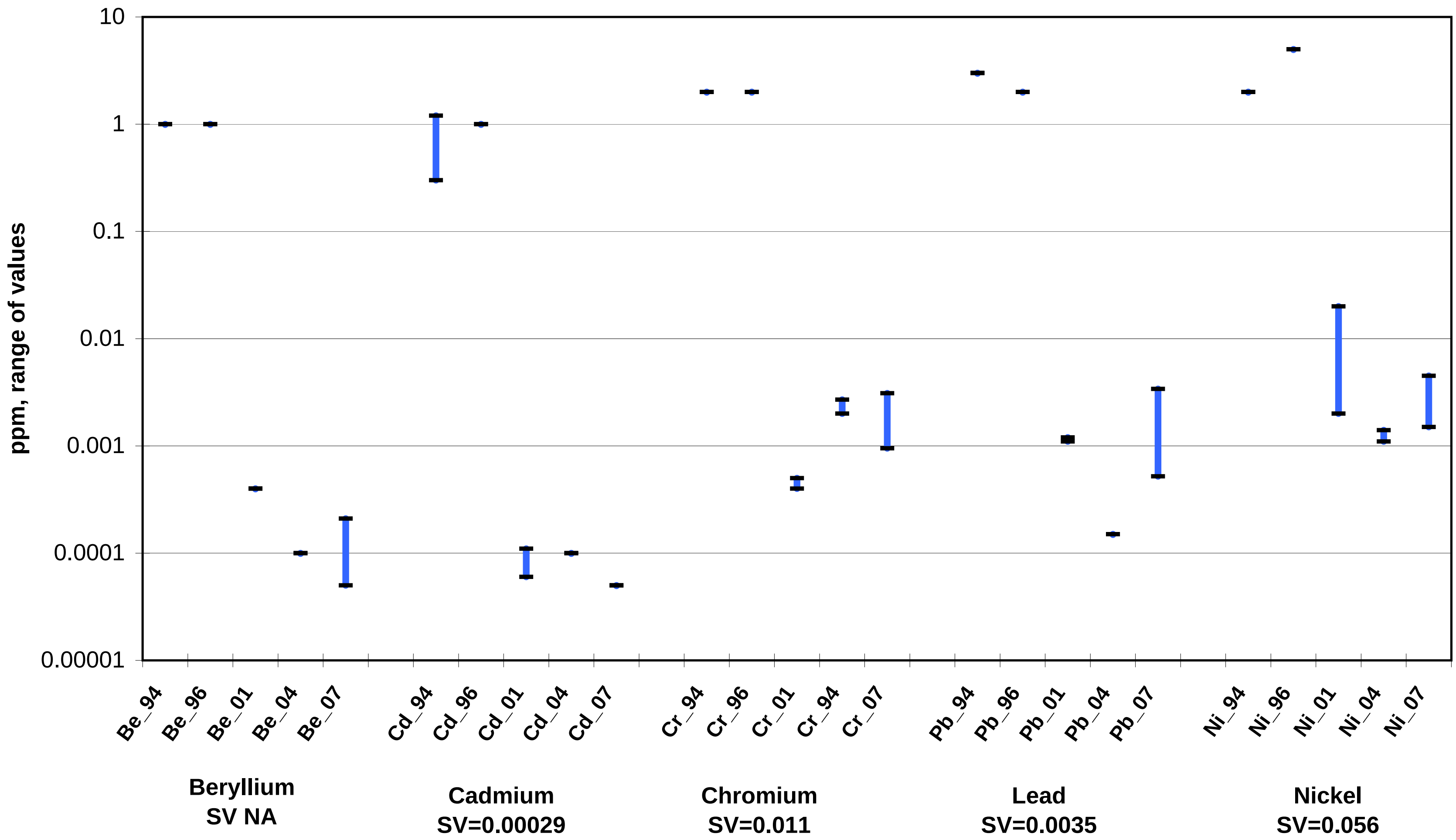
The dioxins and furans in the 2007 data were predominately higher chlorinated dioxins (HxCDD, HpCDD, and OCDD). Lower chlorinated dioxins (PeCDD and TCDD) were also present, but furan congeners were not detected (Figure 4-30a). Milk collected in previous sampling events, particularly 2001 Arthur Johnson Farm milk, indicates little to no presence of the lower chlorinated dioxins, and an increased presence of all furans (Figure 4-30b). The presence of TCDD and PeCDD in the 2007 milk samples contributes to the higher TEQ for milk in 2007, since these congeners are more toxic and have high TEFs (Table 3-1).

Figure 4-1: Average Metals Emission Rates from Montgomery County RRF Stack



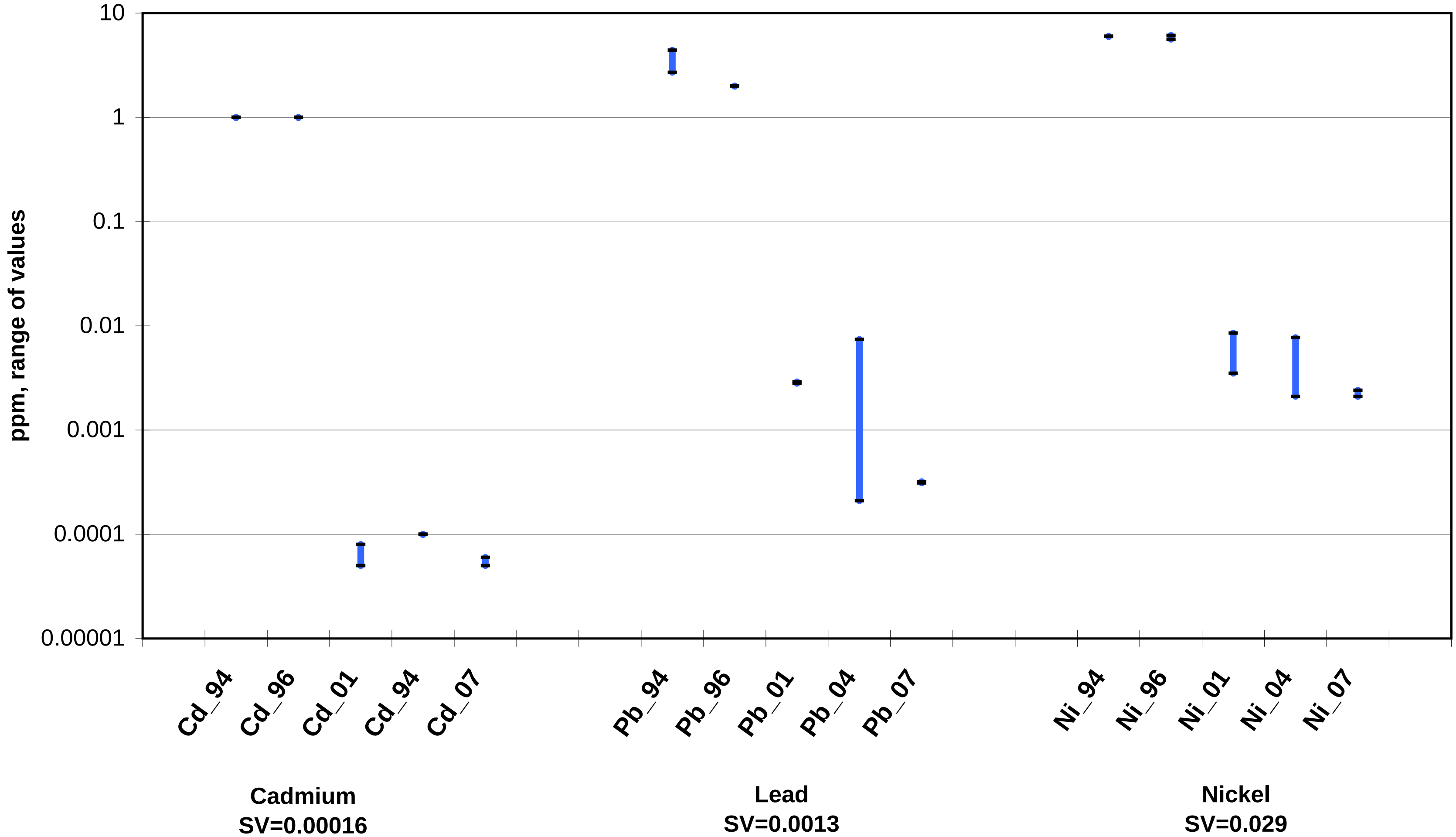
J:\pubs\mw97\projects\4739001\600\figure51metem.xls

Figure 4-2: Total Metals Detected in Surface Water Pond 2:
Pre-Operational ('94) and Operational Phase ('96, '01, '04, '07) Ranges



SV - Screening Value (see Table 3-2)
NA - Not available

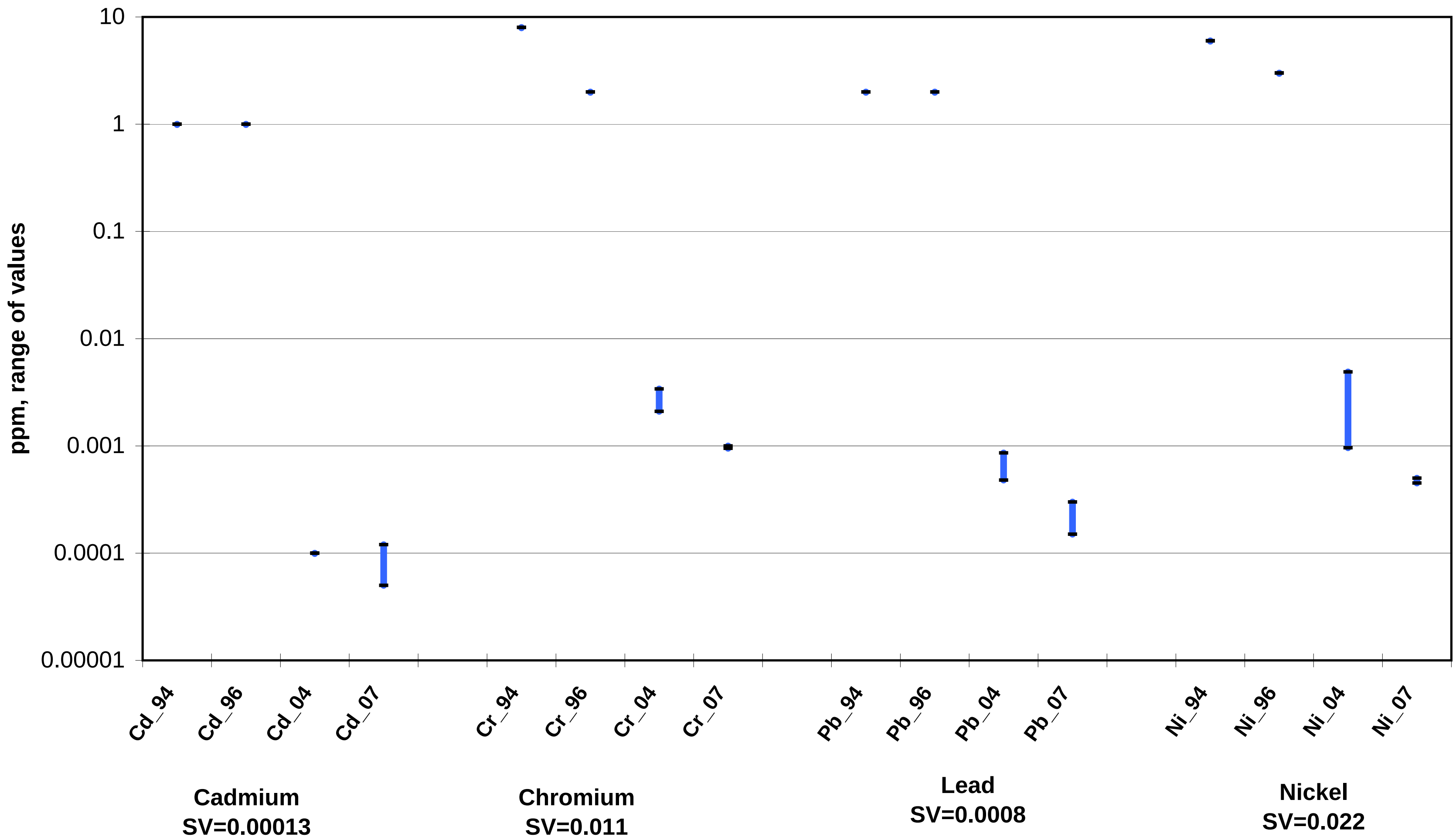
Figure 4-3: Total Metals Detected in Surface Water Pond 3:
Pre-Operational ('94) and Operational Phase ('96, '01, '04, '07) Ranges



SV - Screening Value (Table 3-2)

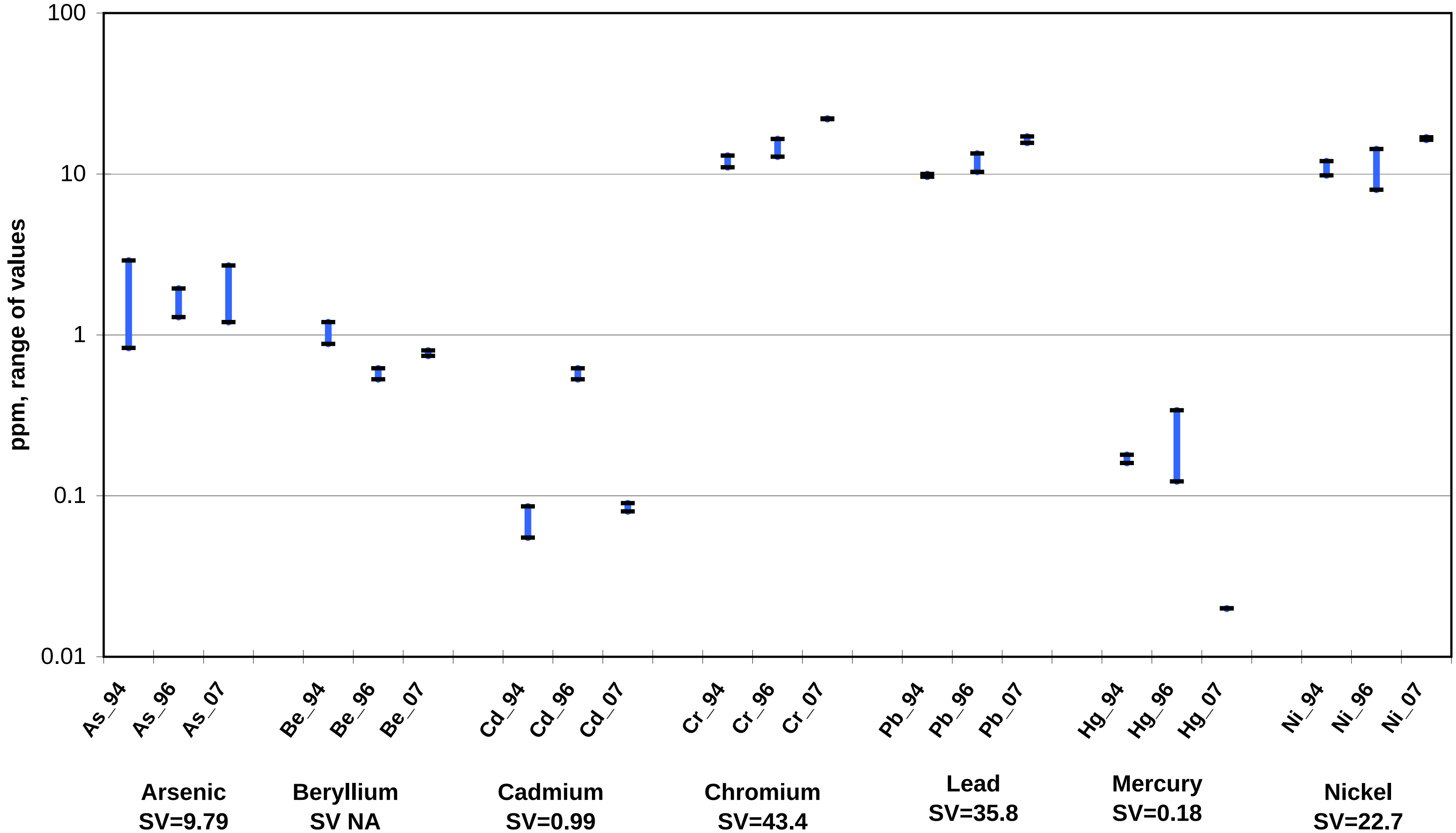
Fig 4-3 2007 metals water Pond 3.xls 4-3
7/14/20084:47 PM

Figure 4-4: Total Metals Detected in Surface Water Pond 5: Pre-Operational ('94) and Operational Phase ('96, '04, '07) Ranges



SV - Screening Value (see Table 3-2)

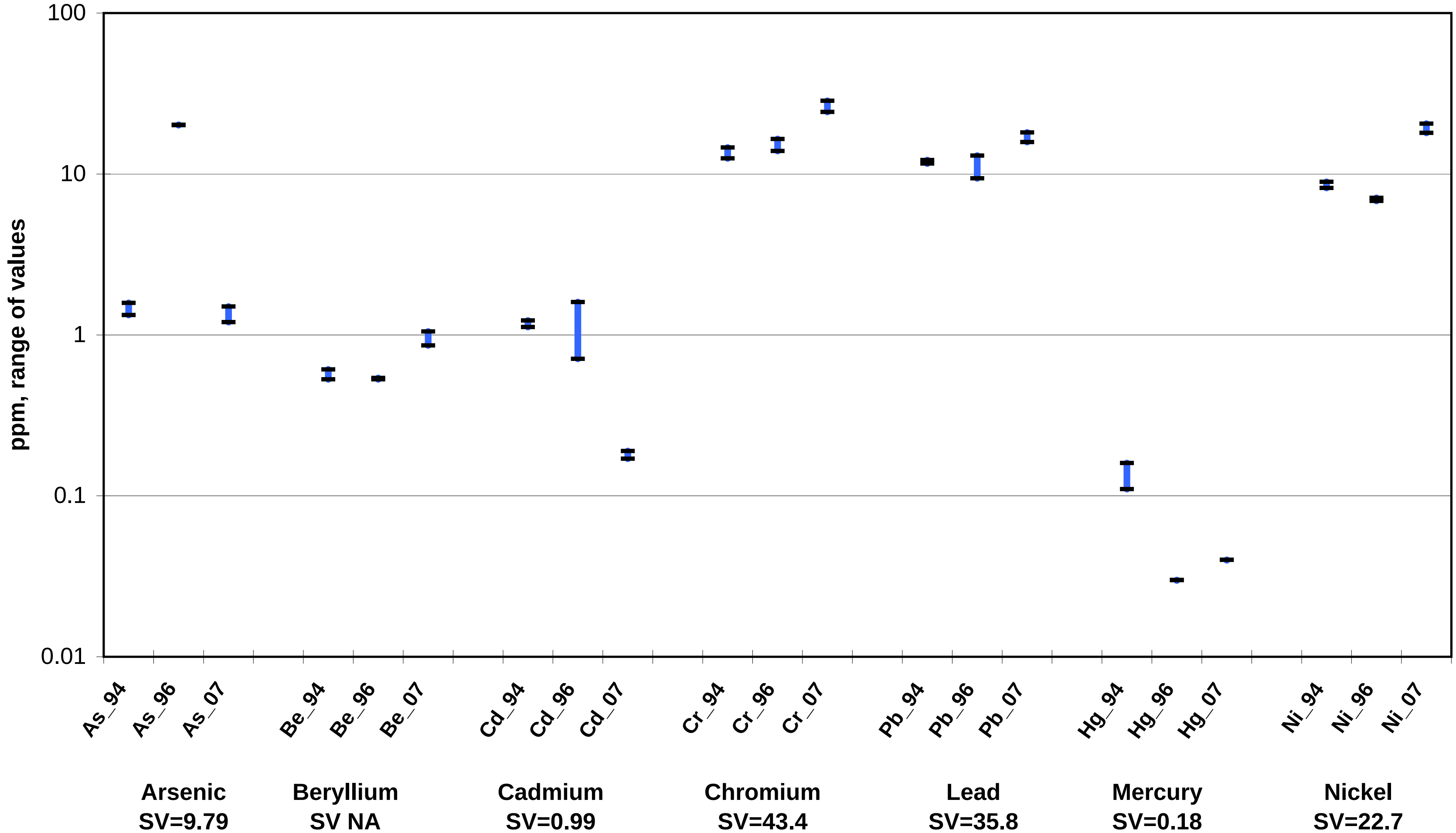
Figure 4-5: Metals Detected in Sediment Pond 2:
Pre-Operational ('94) and Operational Phase ('96, '07) Ranges



SV - Screening Value (see Table 3-2)
NA - Not Available

Fig 4-5 2007 metals sediment Pond 2.xls 4-5
7/14/20084:48 PM

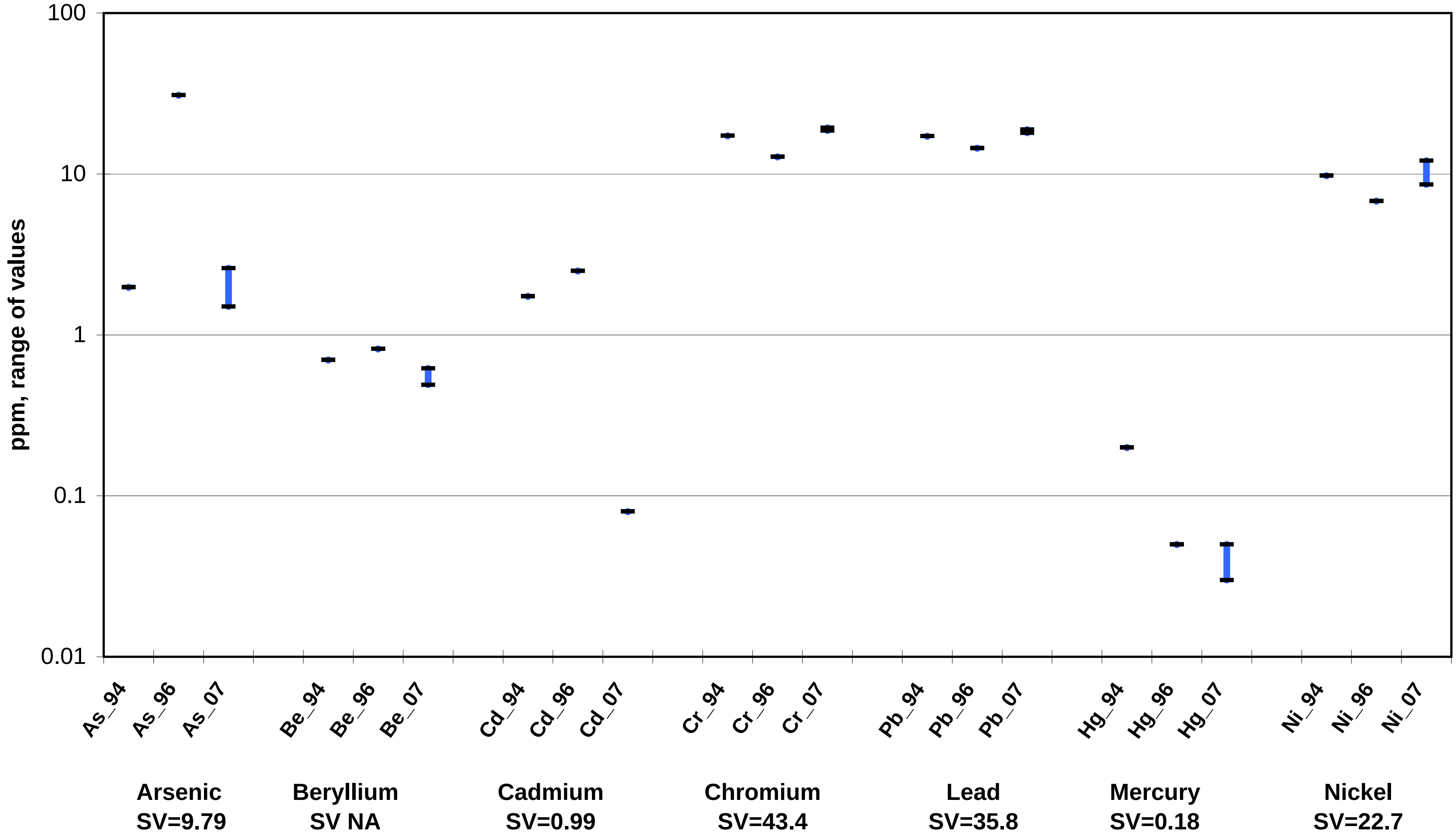
Figure 4-6: Metals Detected in Sediment Pond 3:
Pre-Operational ('94) and Operational Phase ('96, '07) Ranges



SV - Screening Value (see Table 3-2)
NA - Not Available

Fig 4-6 2007 metals sediment Pond 3.xls 4-6
7/14/20084:48 PM

Figure 4-7: Metals Detected in Sediment Pond 5:
Pre-Operational ('94) and Operational Phase ('96, '07) Ranges



SV - Screening Value (see Table 3-2)
NA - Not Available

Fig 4-7 2007 metals sediment Pond 5.xls 4-7
7/14/20084:48 PM

Figure 4-8
Metals Detected in Bluegill Sunfish from Pond 2:
Pre-Operational ('94) and Operational Phase ('96, '01, '04, '07) Ranges

Figure 4-8a: Arsenic

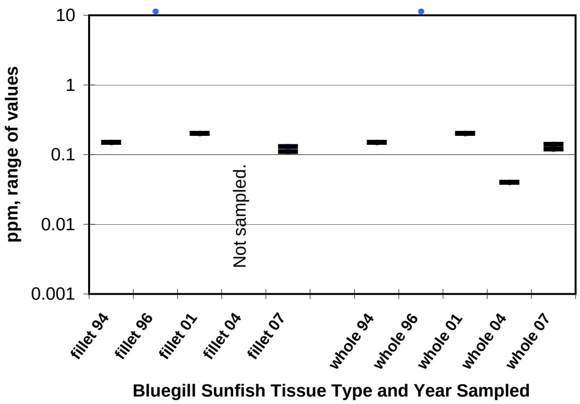


Figure 4-8b: Chromium

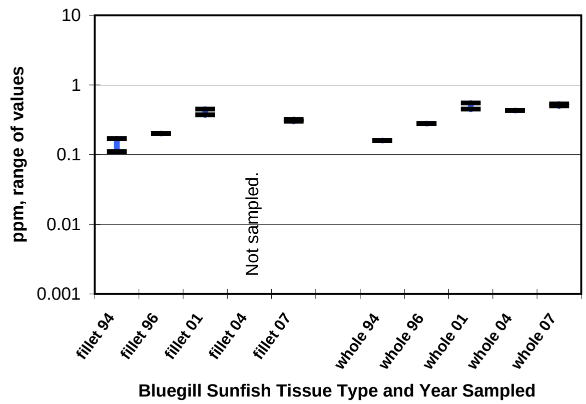


Figure 4-8c: Lead

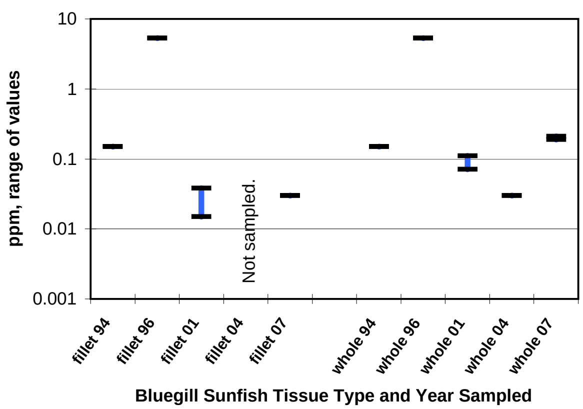


Figure 4-8d: Mercury

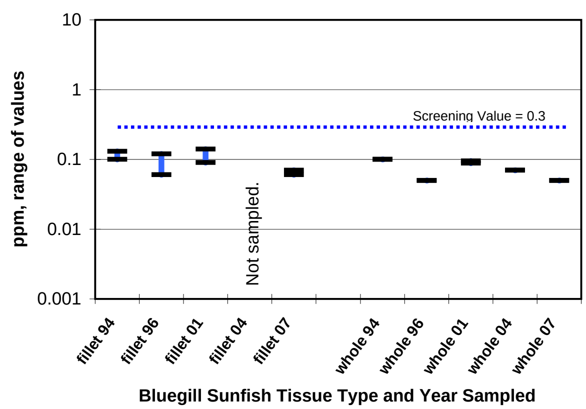
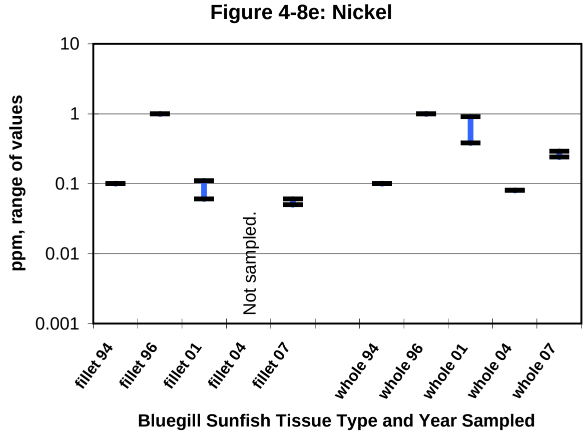
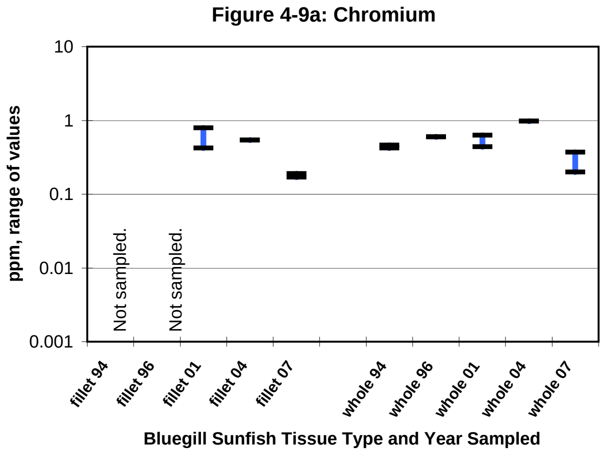


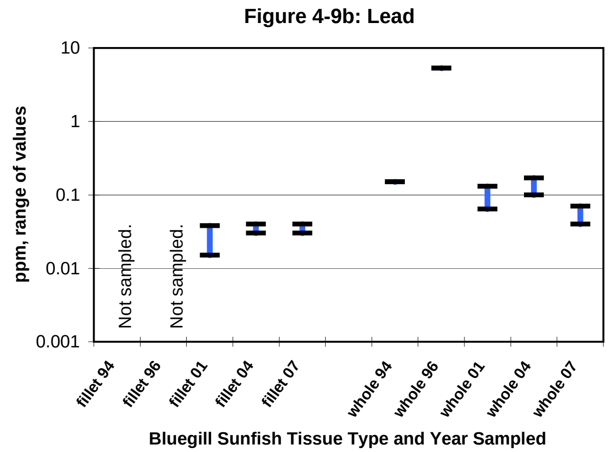
Figure 4-8e: Nickel

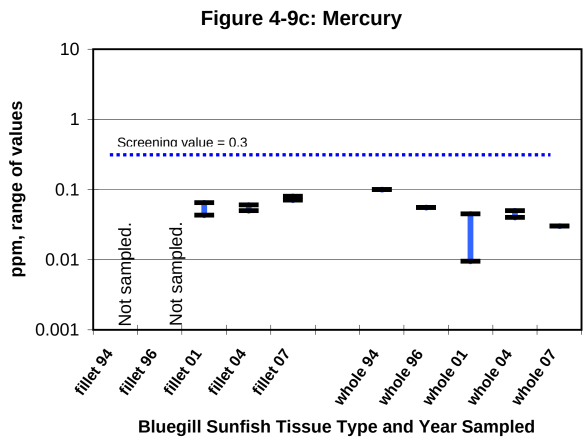


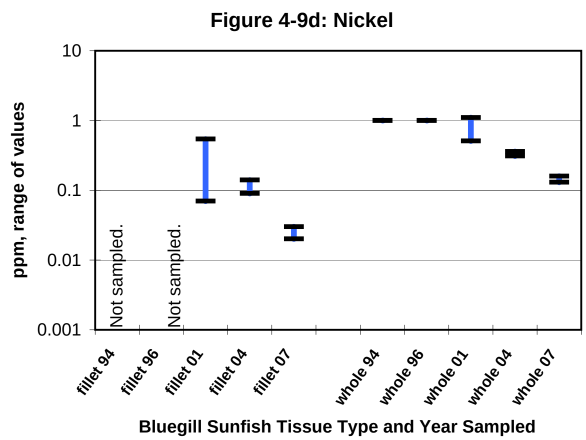
Notes:
ppm = parts per million dry weight

Figure 4-9
Metals Detected in Bluegill Sunfish from Pond 3:
Pre-Operational ('94) and Operational Phase ('96, '01, '04, '07) Ranges









Notes:
ppm = parts per million dry weight

Figure 4-10
Metals Detected in Largemouth Bass from Pond 3: Operational Phase ('01, '04, '07) Ranges

Figure 4-10a: Cadmium

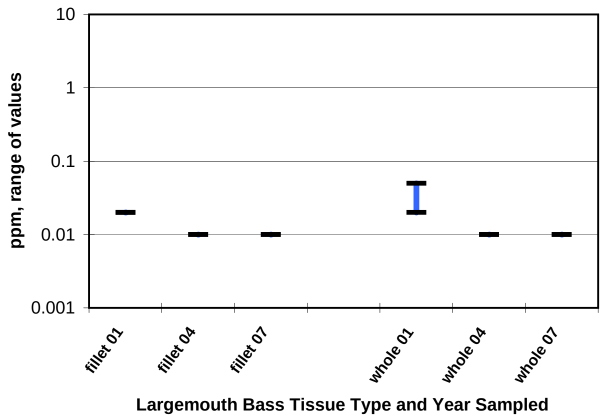


Figure 4-10b: Chromium

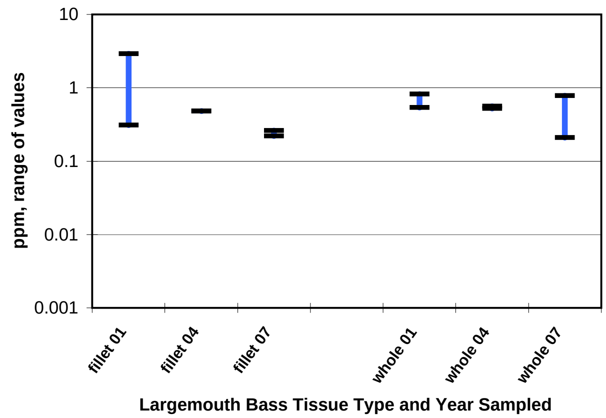


Figure 4-10c: Lead

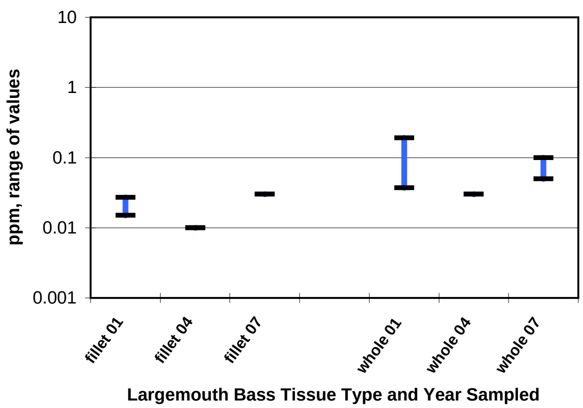


Figure 4-10d: Mercury

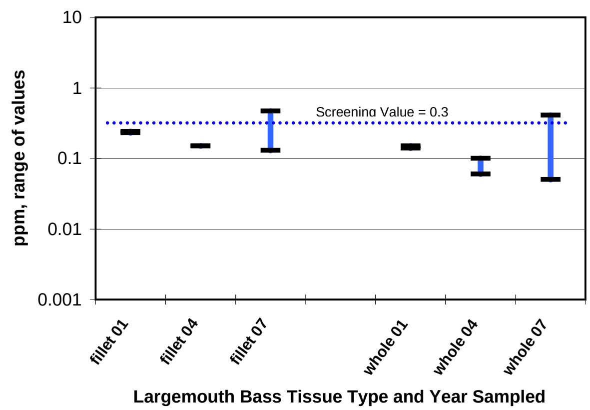
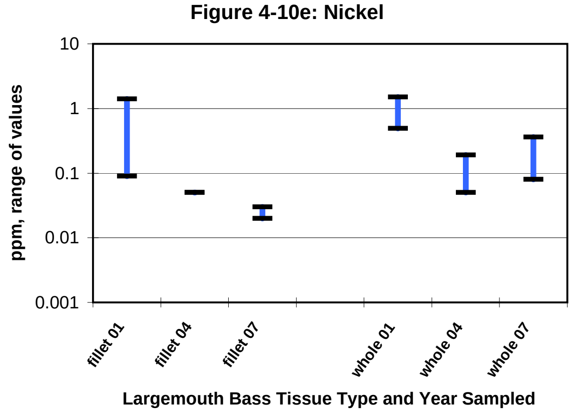
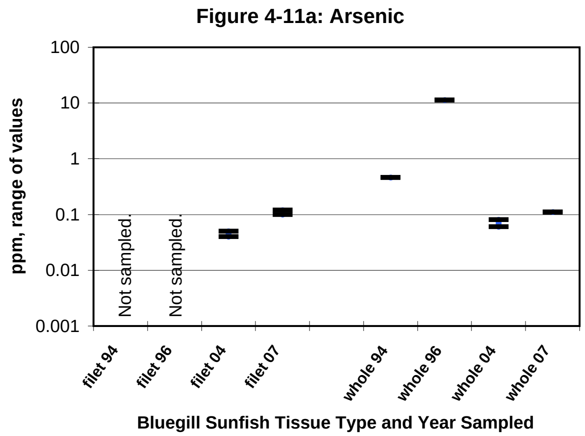


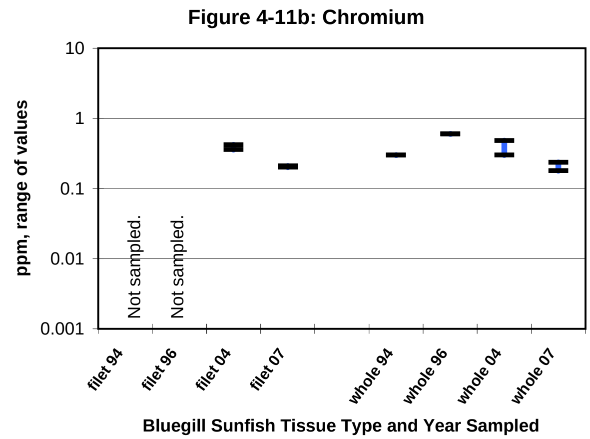
Figure 4-10e: Nickel

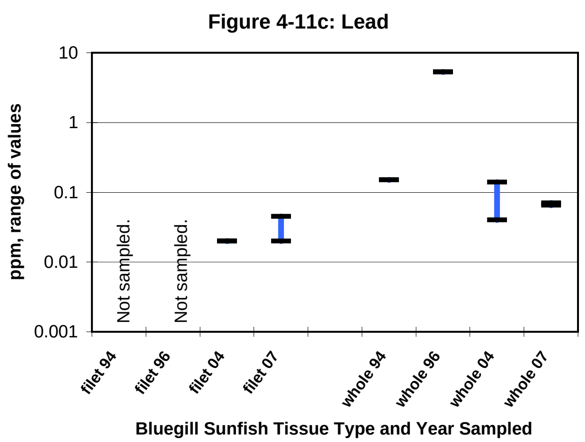


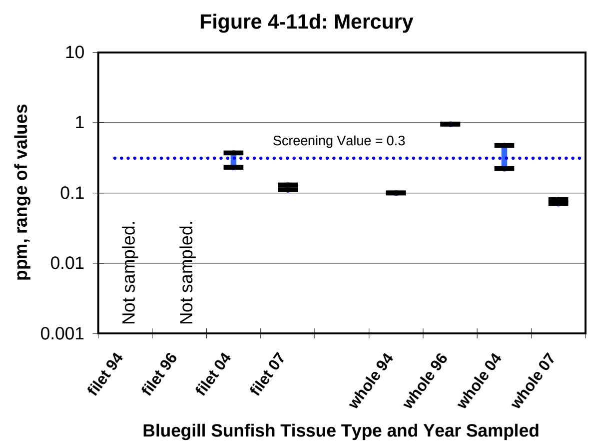
Notes:
ppm = parts per million dry weight

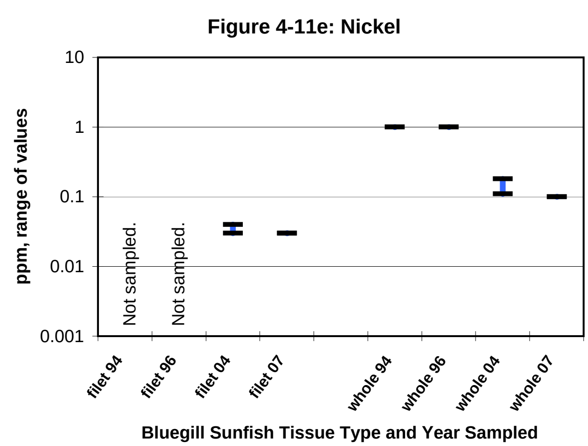
Figure 4-11
Metals Detected in Bluegill Sunfish from Pond 5: Pre-Operational ('94) and Operational Phase ('96, '04, '07) Ranges





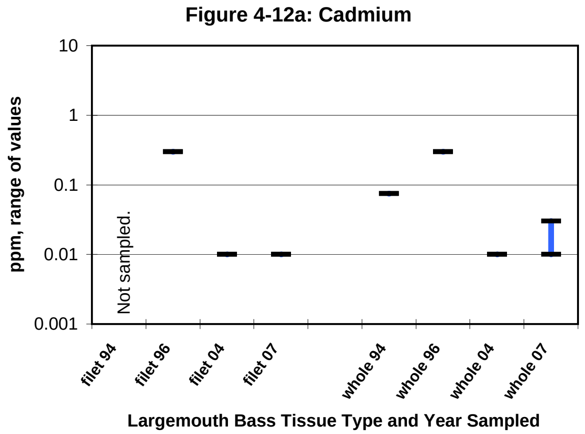


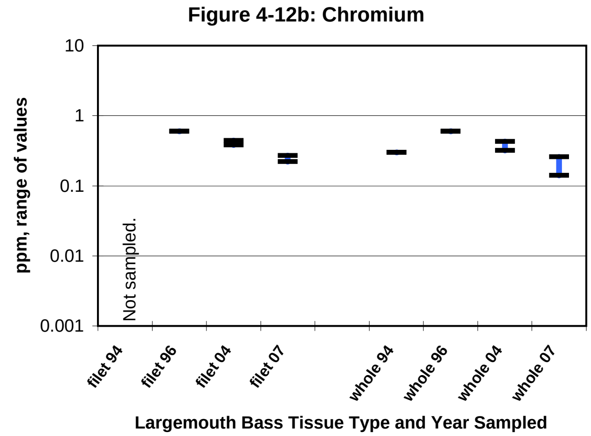


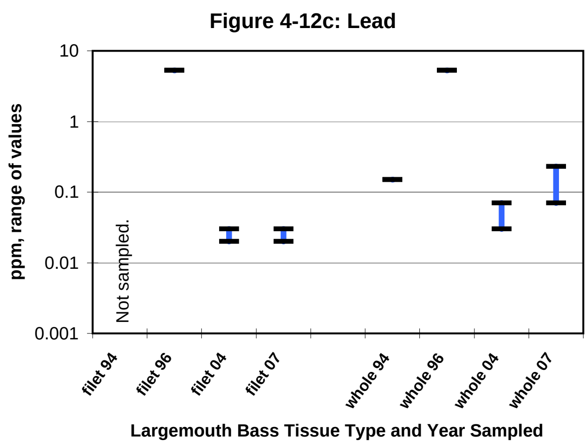


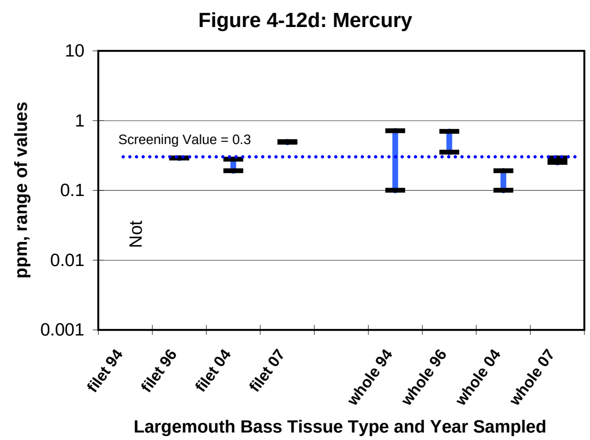
Notes:
ppm = parts per million dry weight

Figure 4-12
Metals Detected in Largemouth Bass from Pond 5: Pre-Operational ('94) and Operational Phase ('96, '04, '07) Ranges









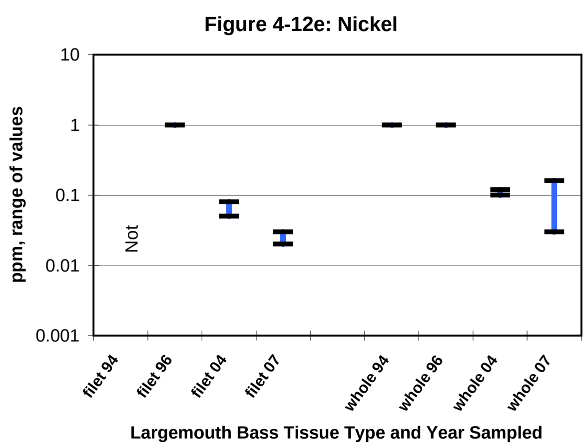
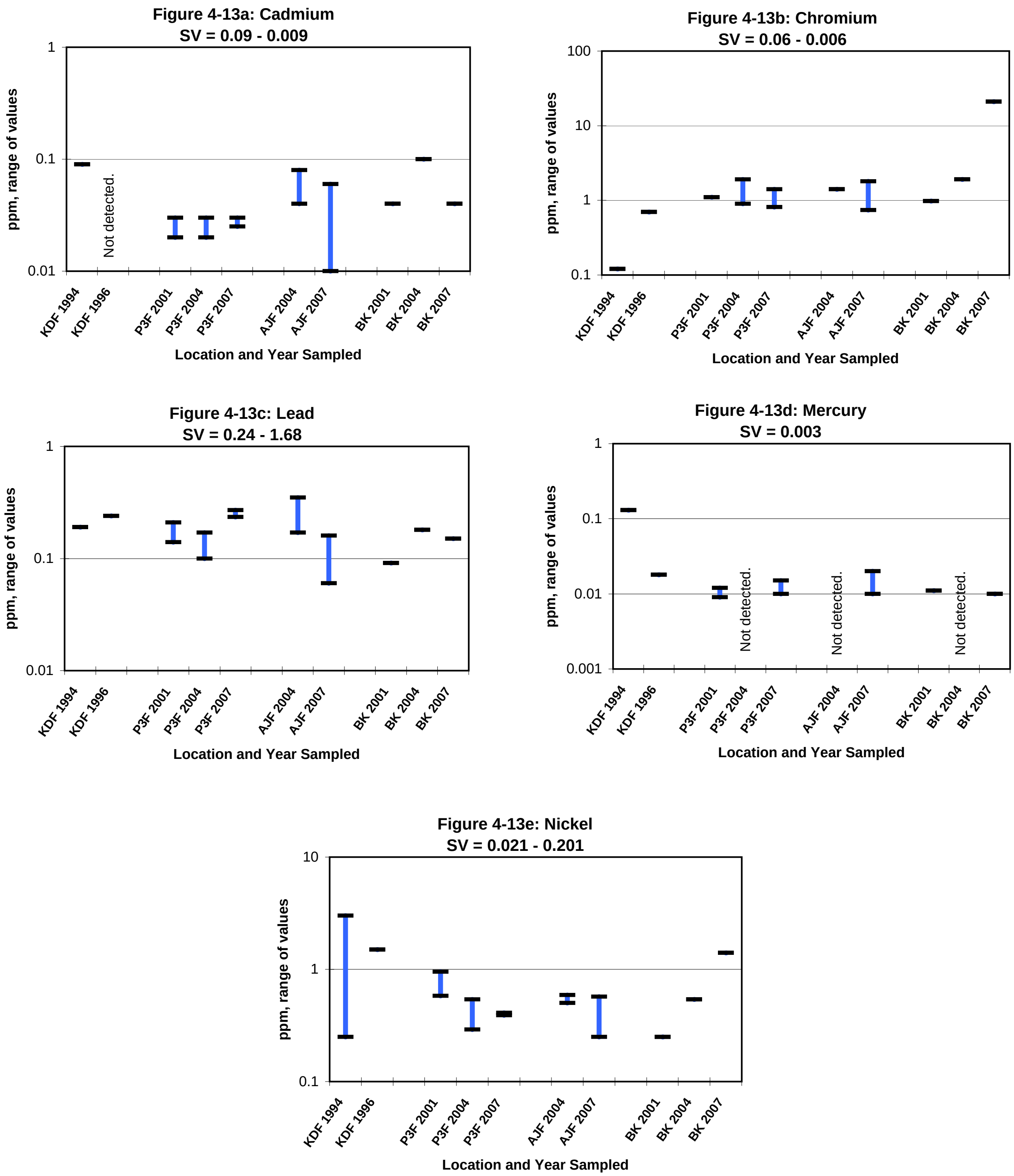
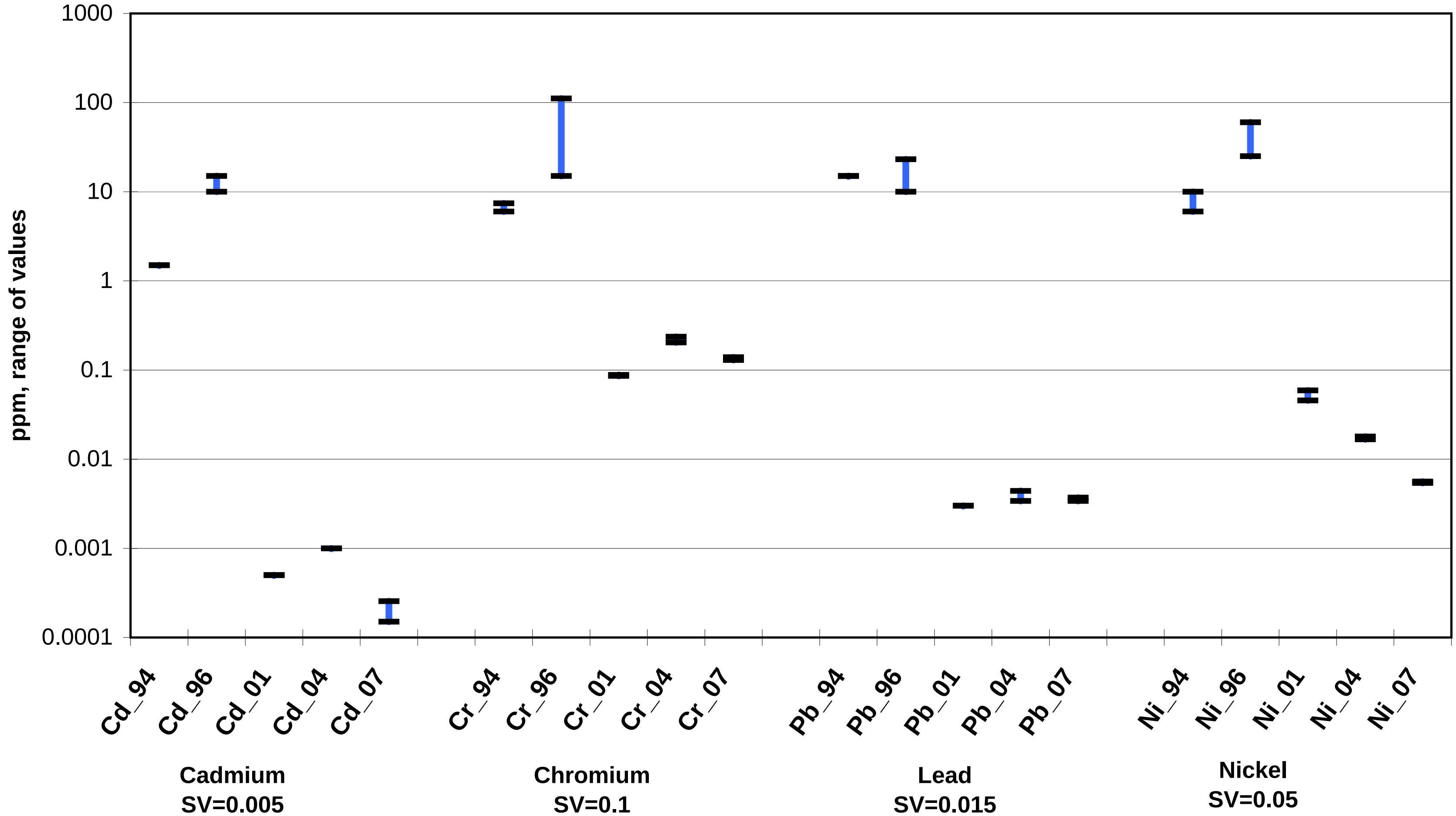


Figure 4-13
Metals Detected in Hay:
Pre-Operational ('94) and Operational Phase ('96, '01, '04, '07) Ranges



Notes:
KDF = Kingsbury Dairy Farm
P3F = Pond 3 Farm
AJF = Arthur Johnson Farm
BK = Background Location
ppm = parts per million dry weight
SV - Screening Value (see Table 3-2)

Figure 4-14: Metals Detected in Milk Samples: Pre-Operational ('94) and Operational Phase ('96, '01, '04, '07) Ranges



SV - Screening Value (see Table 3-2)

Figure 4-15: Pattern of PCDD/PCDF emissions from Montgomery County RRF
(Basis: Average of All Stack Tests 1995 - 2007)

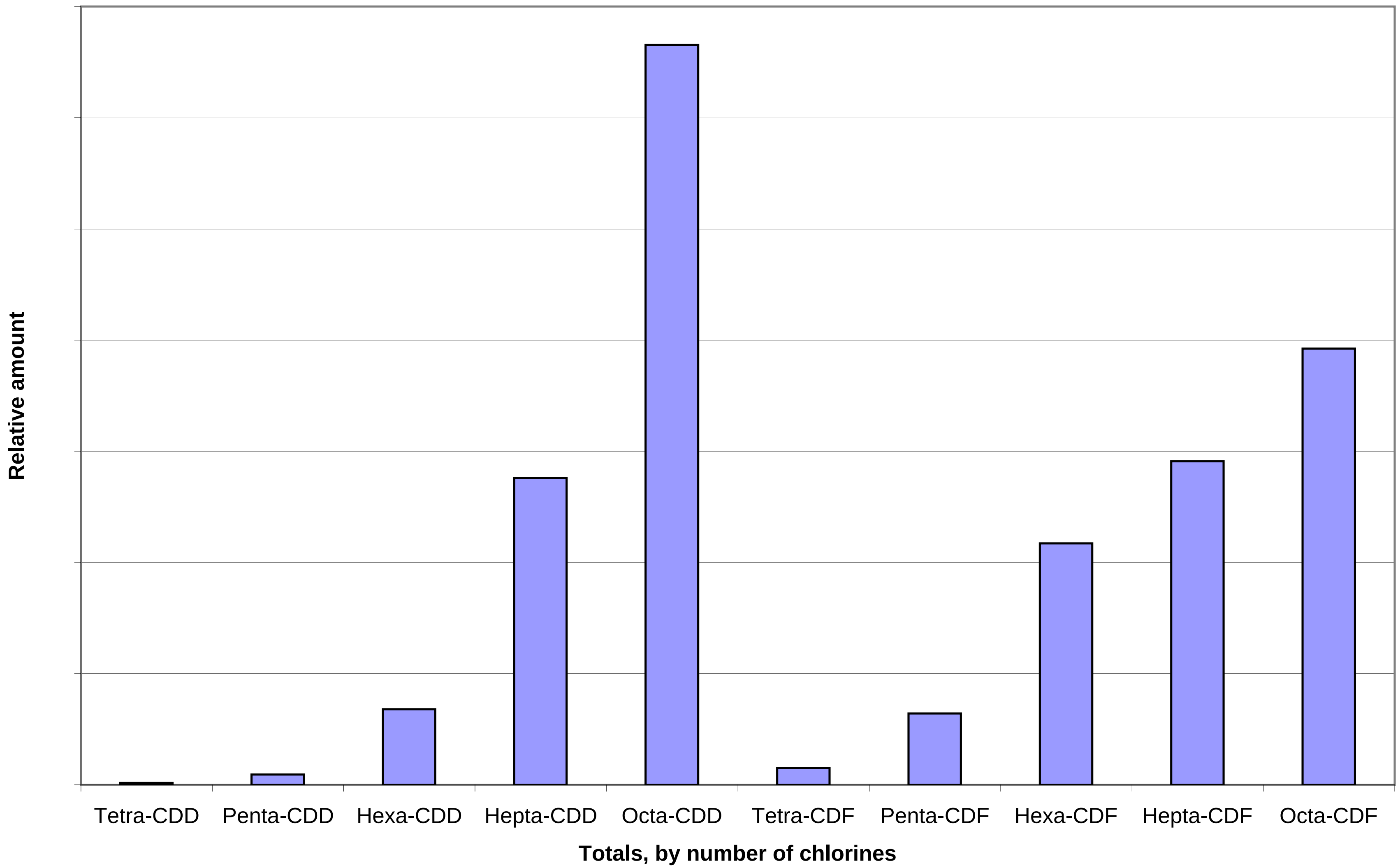


Figure 4-16: Range of TCDD Achieved Detection Limits in Pond 2 Surface Water

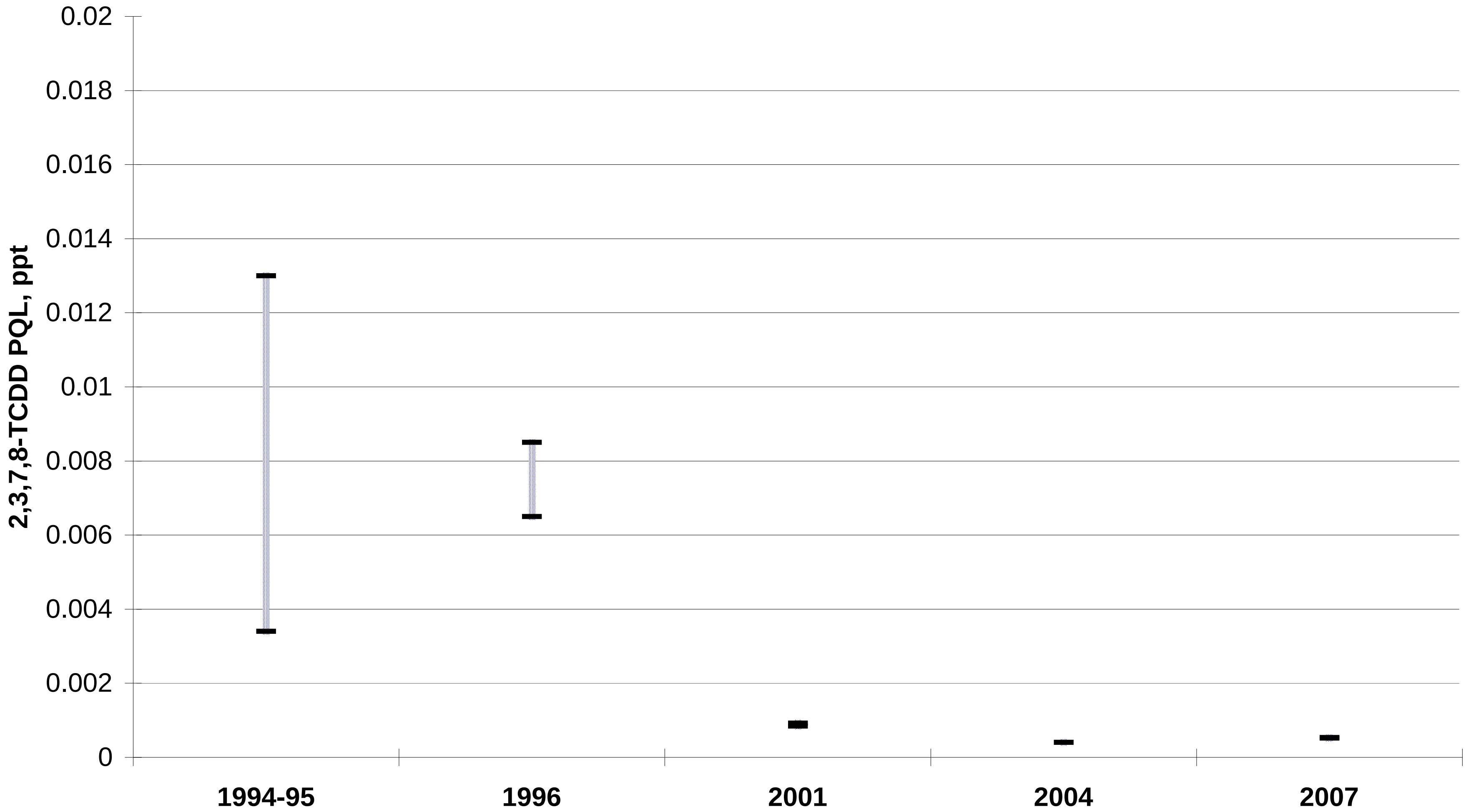
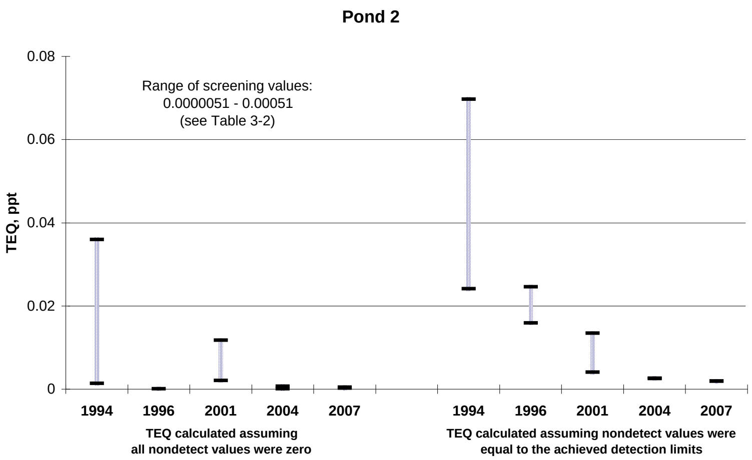
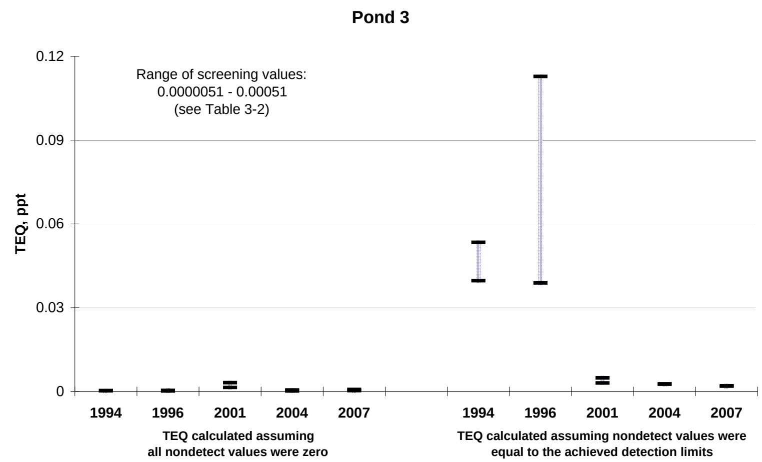


Figure 4-17: PCDDs/PCDFs in Surface Water Ponds 2, 3 and 5: Pre-Operational ('94) and Operational Phase ('96, '01, '04, '07) TEQ Ranges





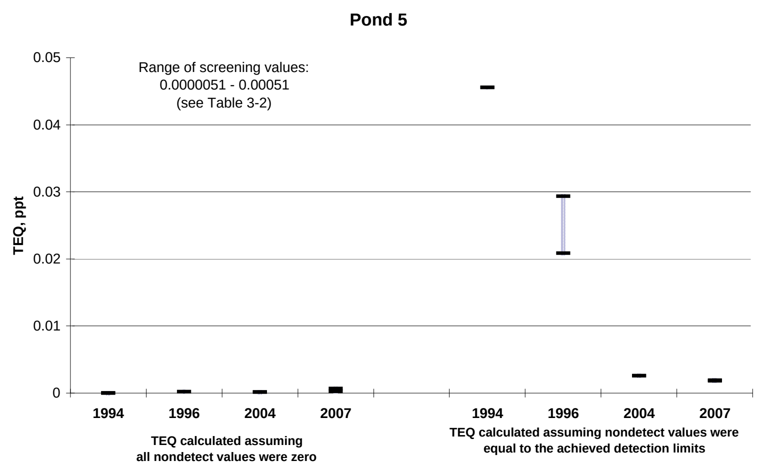
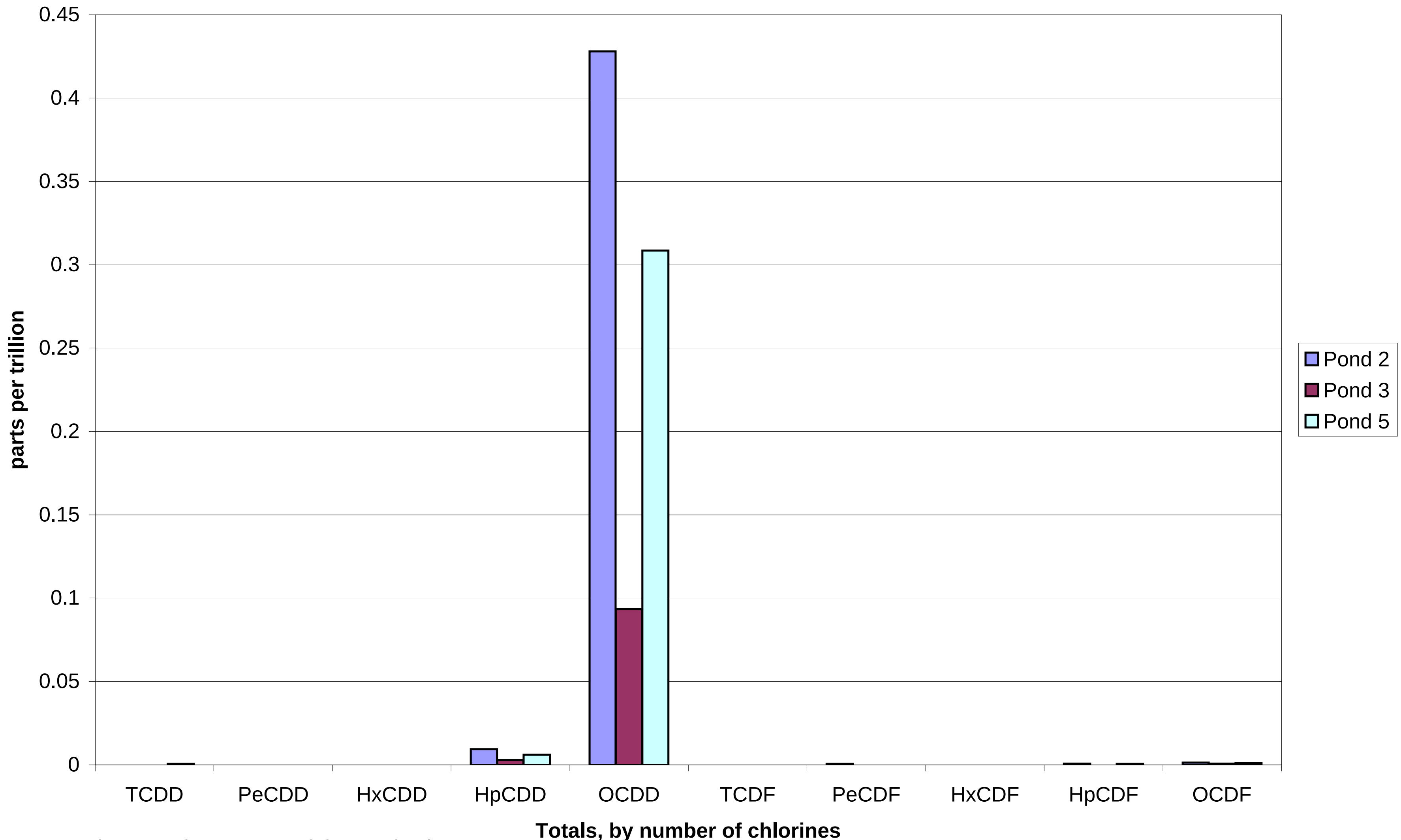
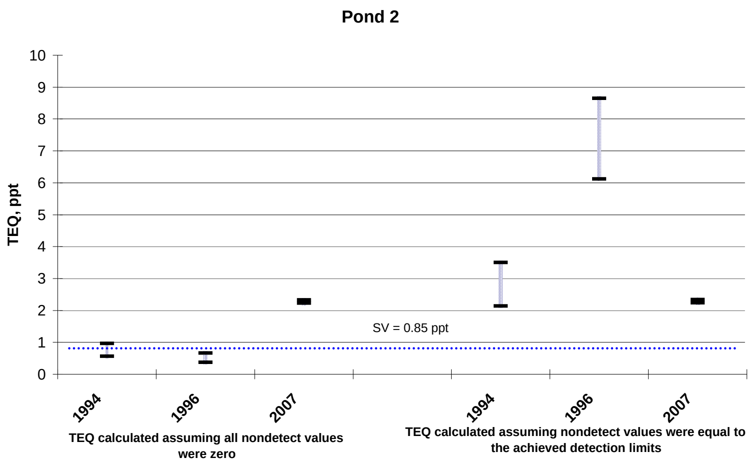


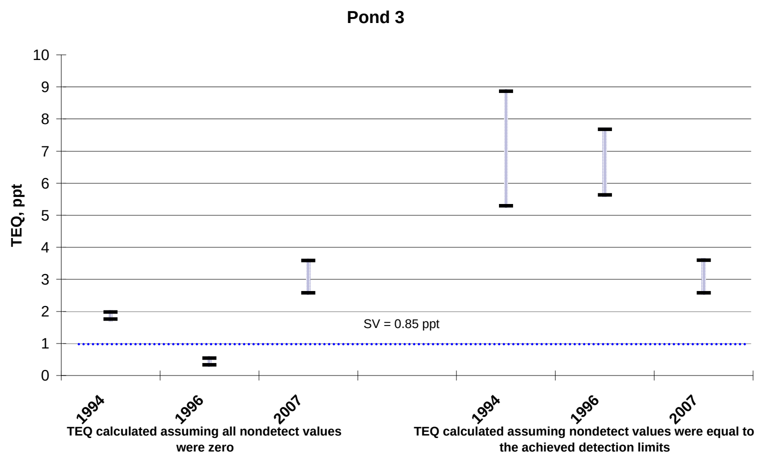
Figure 4-18 Distribution of PCDD/PCDF in 2007 Surface Water Samples

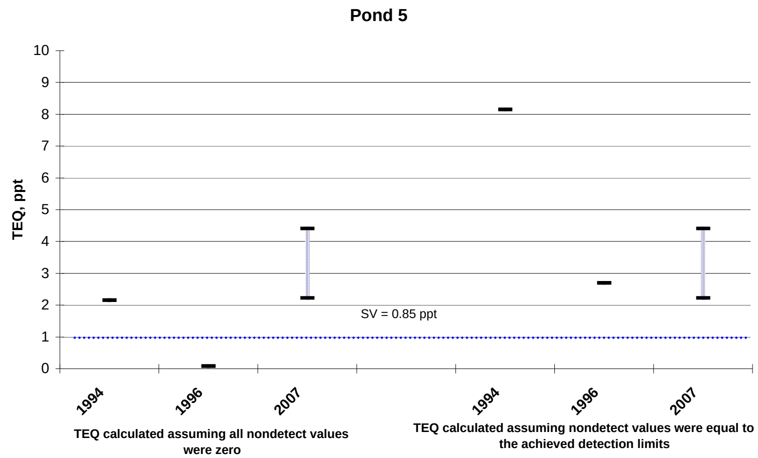


Concentrations are the average of detected values.

Figure 4-19: PCDDs/PCDFs in Sediment Ponds 2, 3 and 5: Pre-Operational ('94) and Operational Phase ('96, '07) TEQ Ranges

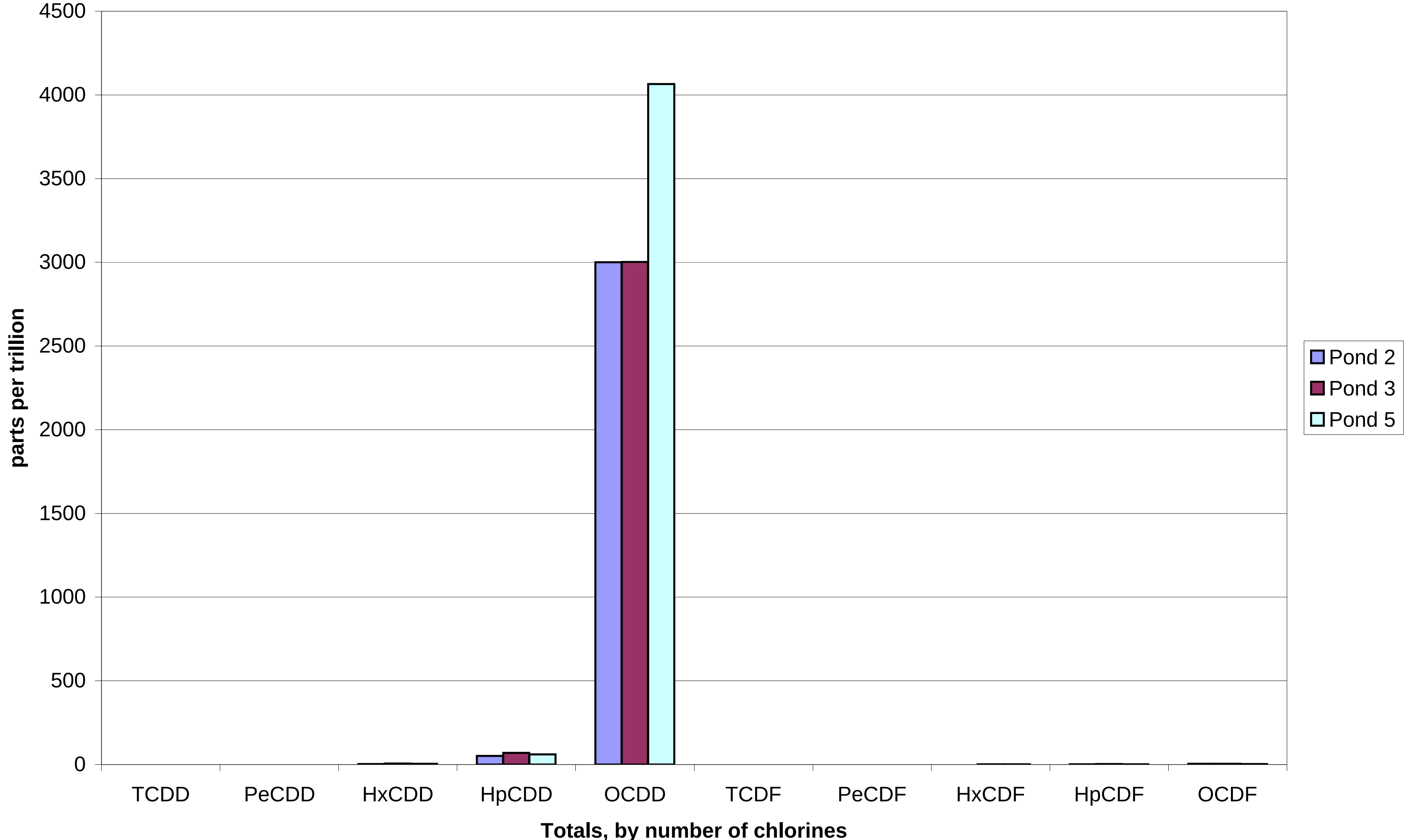






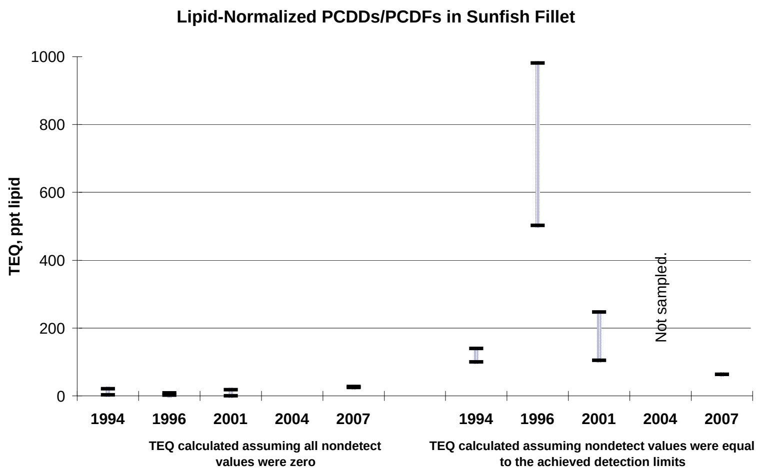
SV - Screening value (see Table 3-2)

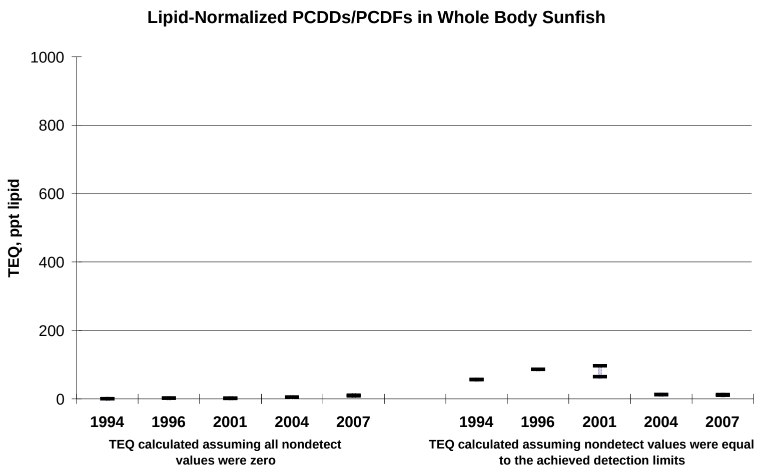
Figure 4-20 Distribution of PCDD/PCDF in 2007 Sediment Samples

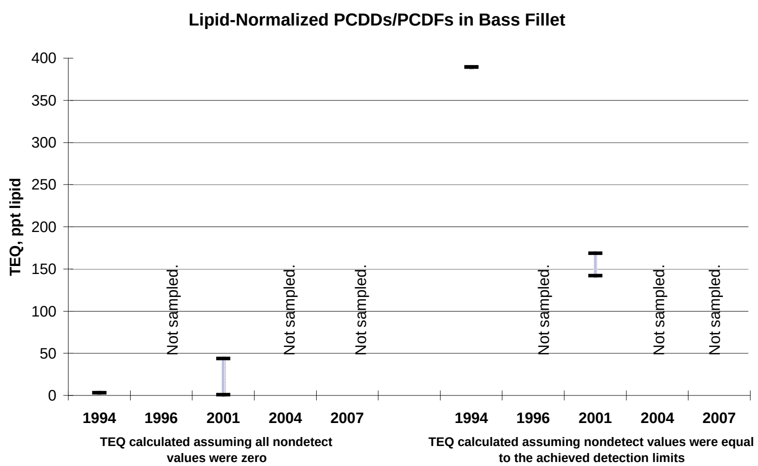


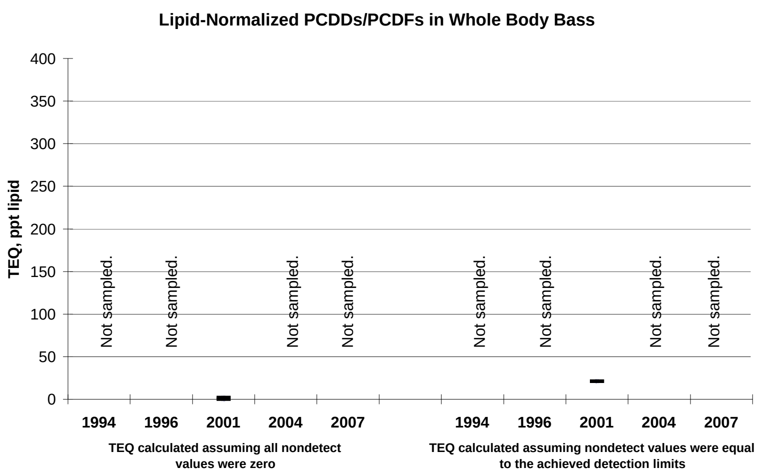
Concentrations are the average of detected values.

Figure 4-21: PCDDs/PCDFs in Fish Pond 2: Pre-Operational ('94) and Operational Phase ('96, '01, '04, '07) TEQ Ranges









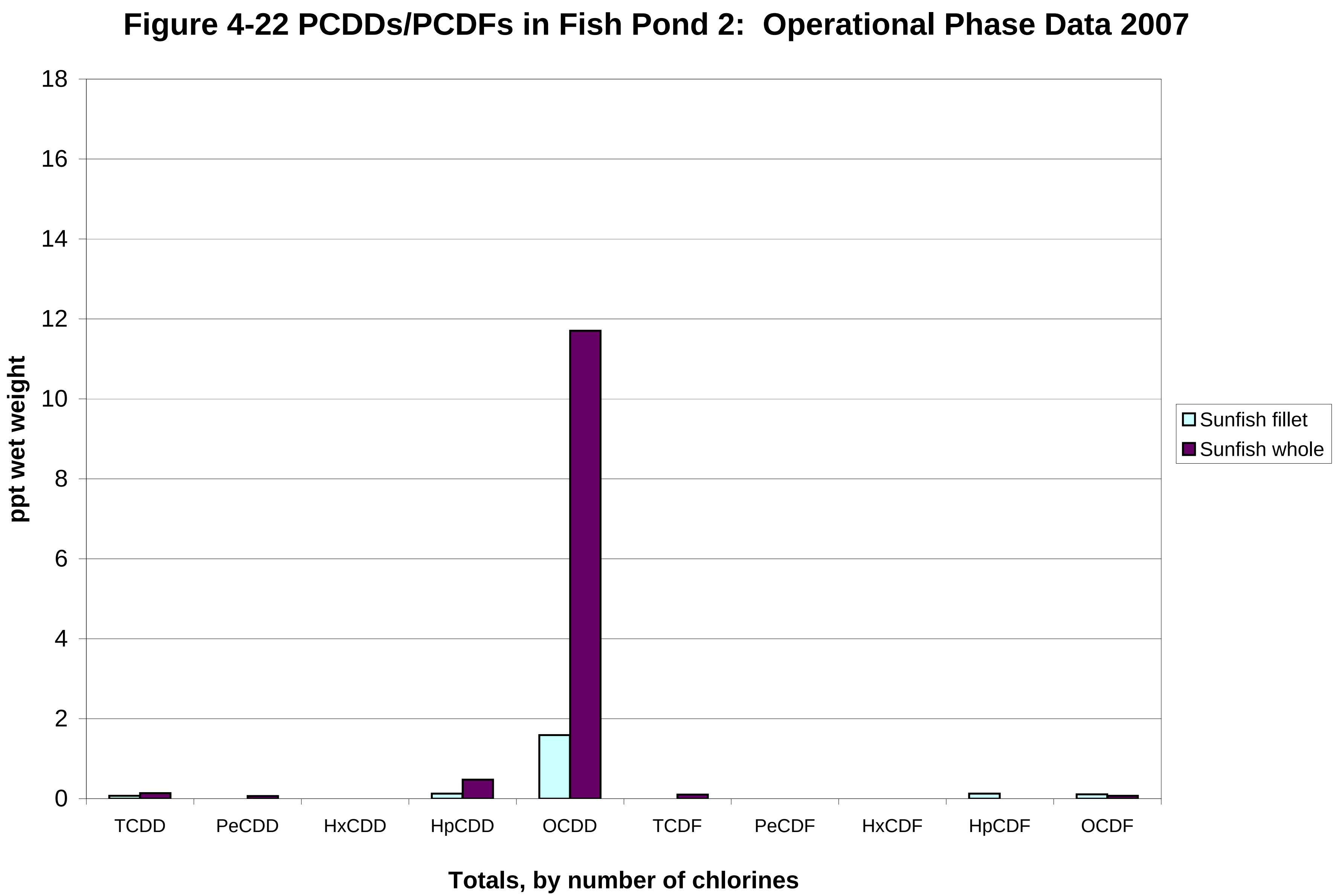


Figure 4-22 PCDDs/PCDFs in Fish Pond 2: Operational Phase Data 2007
18
16
14
12
10
8
6
4
2
0
ppt wet weight
TCDD
PeCDD
HxCDD
HpCDD
OCDD
TCDF
PeCDF
HxCDF
HpCDF
OCDF
Totals, by number of chlorines
Sunfish fillet
Sunfish whole

Figure 4-23: PCDDs/PCDFs in Fish Pond 3: Pre-Operational ('94) and Operational Phase ('96, '01, '04, '07) TEQ Ranges

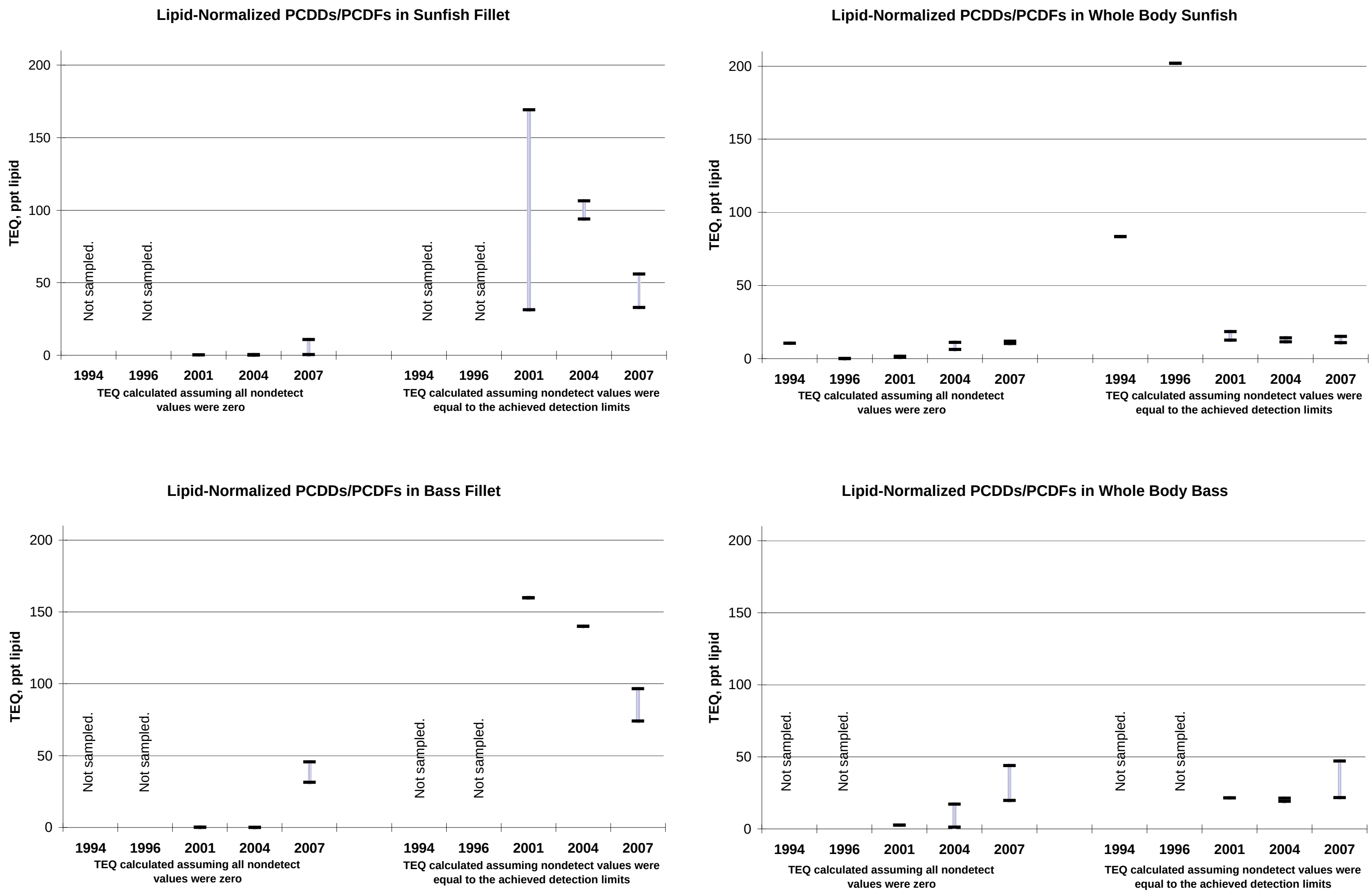
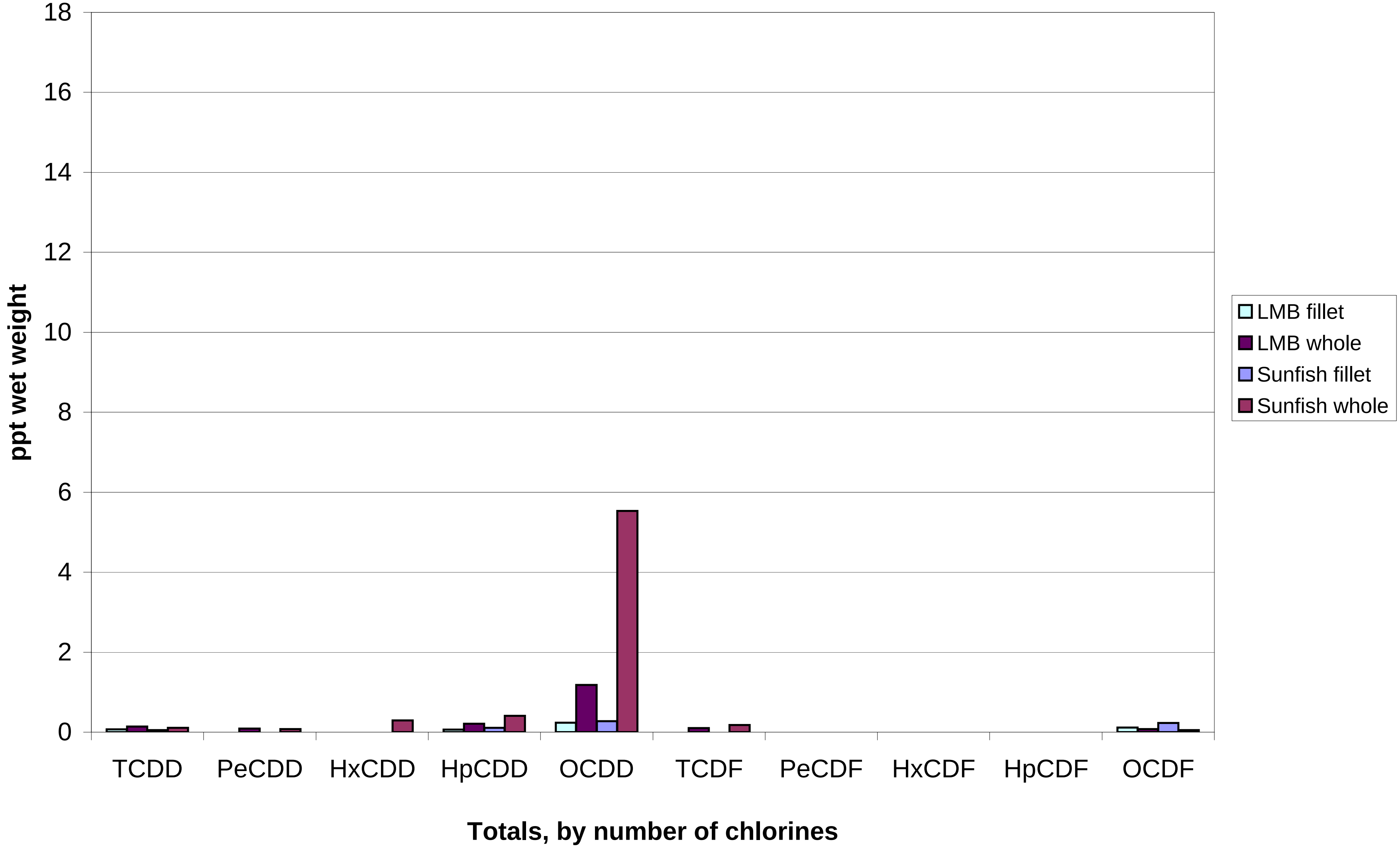
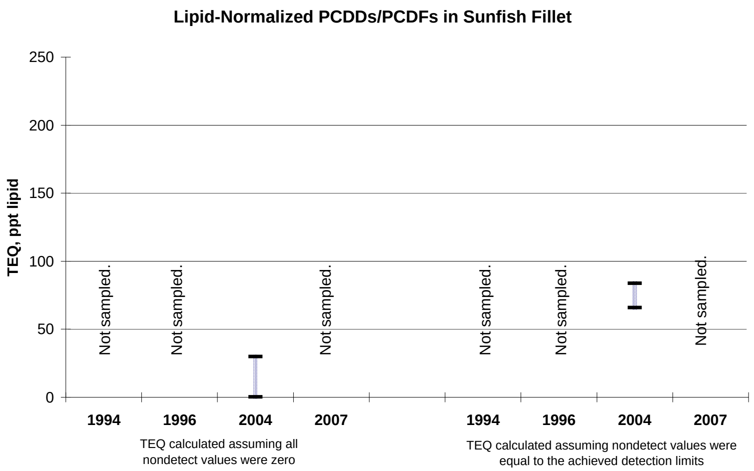


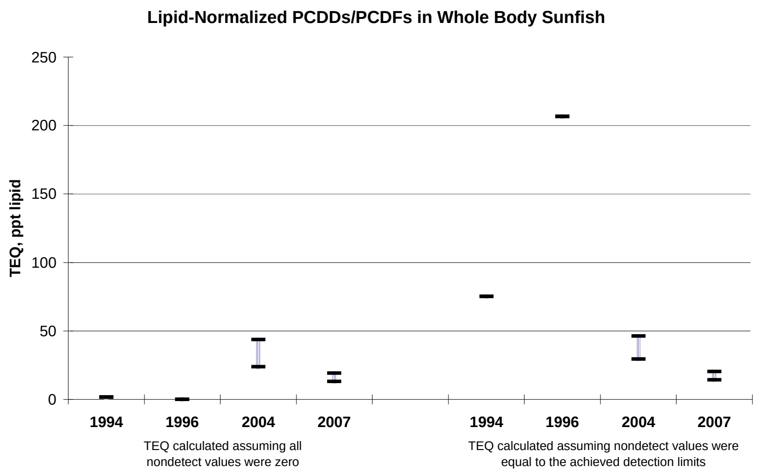
Figure 4-24 PCDDs/PCDFs in Fish Pond 3: Operational Phase Data 2007

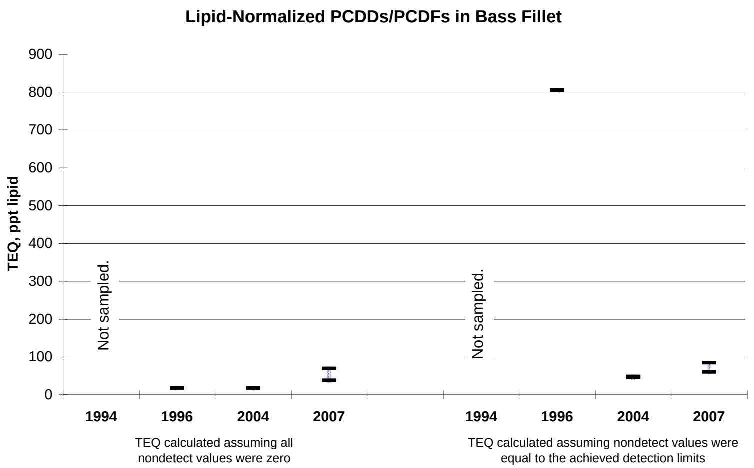


LMB - Largemouth Bass

Figure 4-25: PCDDs/PCDFs in Fish Pond 5: Pre-Operational ('94) and Operational Phase ('96, '04, '07) TEQ Ranges







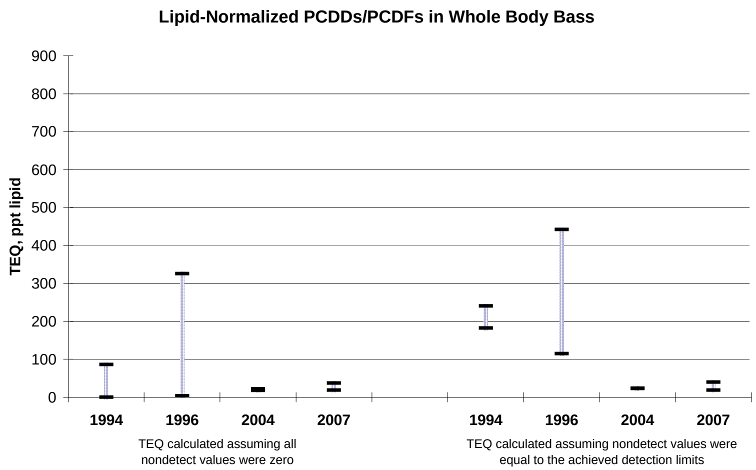
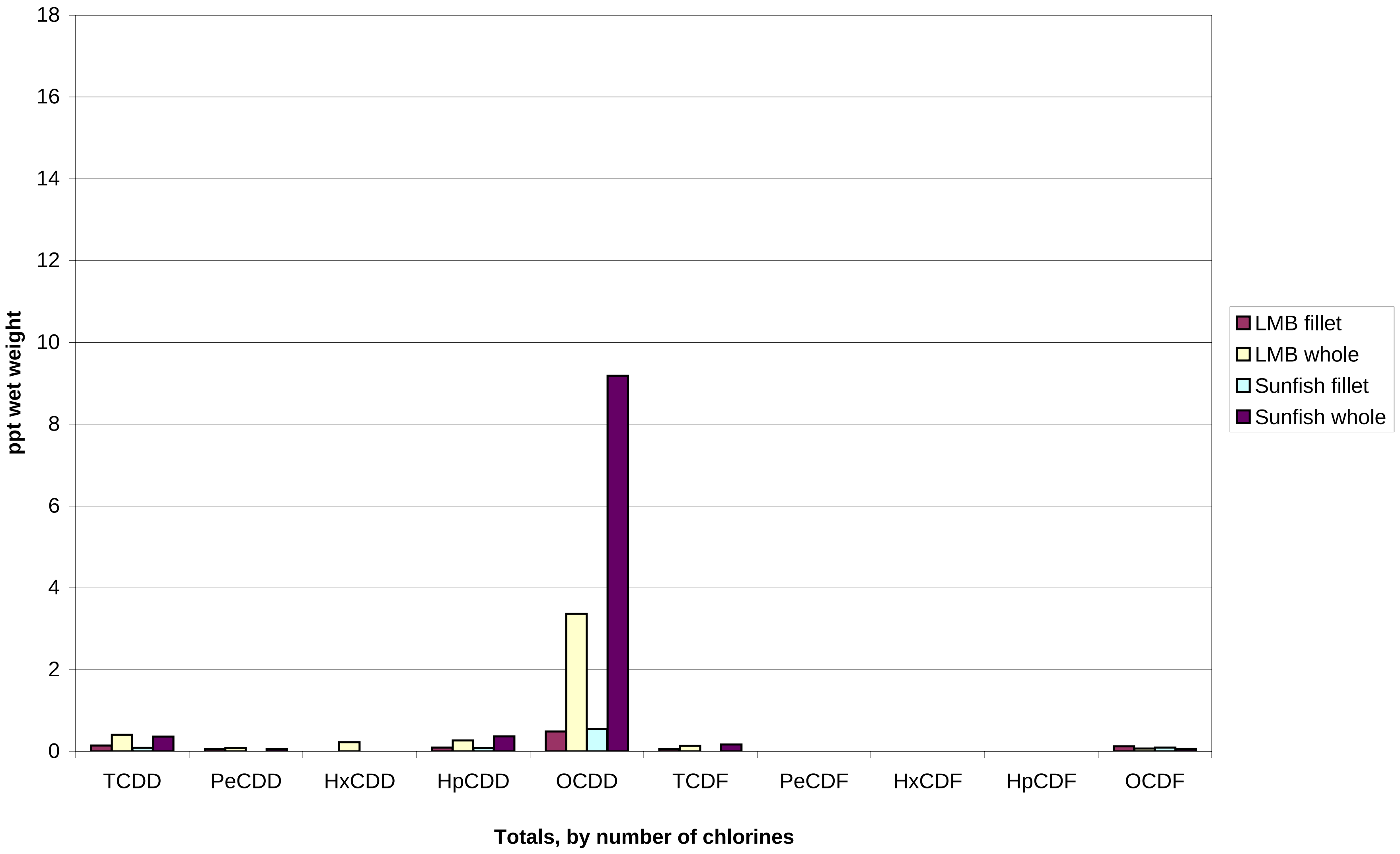
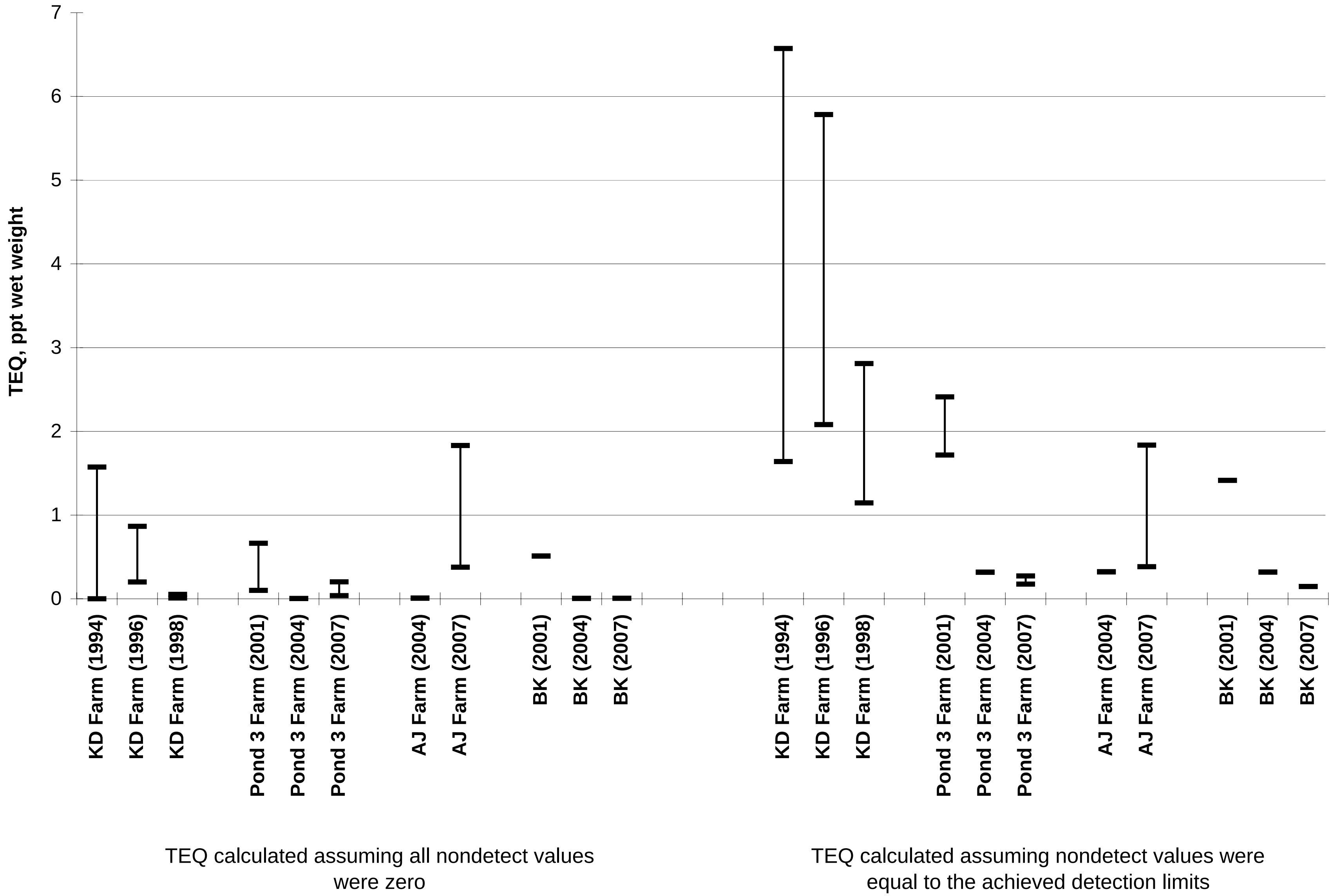


Figure 4-26 PCDDs/PCDFs in Fish Pond 5: Operational Phase Data 2007



LMB - Largemouth Bass

Figure 4-27: PCDDs/PCDFs in Hay: Pre-Operational (Kingsbury Dairy Farm '94) and Operational Phase: Kingsbury Dairy Farm ('96, '98), Pond 3 Farm ('01, '04, '07), Arthur Johnson Farm ('04, '07) and Background ('01, '04, '07)



KD Farm = Kingsbury Dairy Farm
P3 Farm = Pond 3 Farm
AJ Farm = Arthur Johnson Farm
BK = Background in Lucketts, VA

Fig 4-27 2007 TEQ hay.xls, 4-27
5/29/200911:45 AM

Figure 4-28: PCDD/PCDFs in Hay

Figure 4-28a: PCDDs/PCDFs in Hay: Pond 3 Farm, Arthur Johnson Farm, and Background (Operational Phase '07)

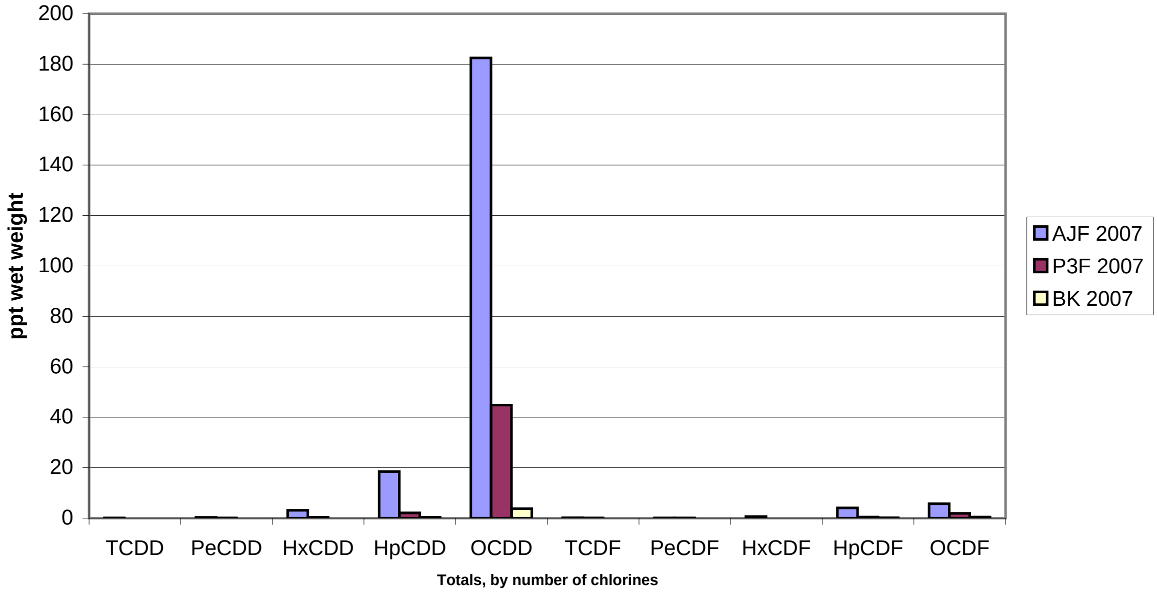
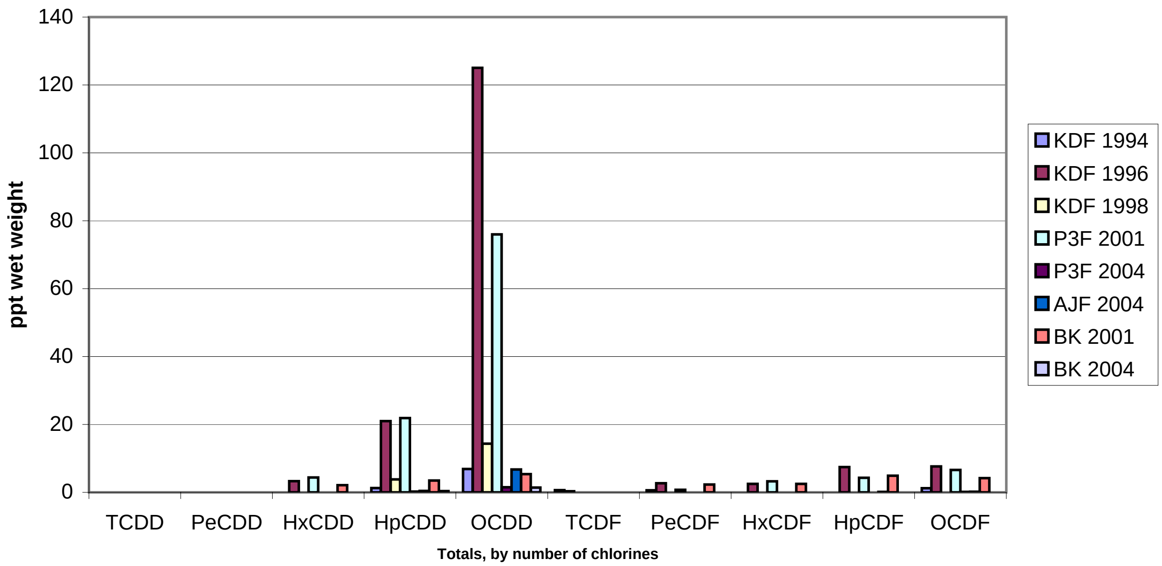
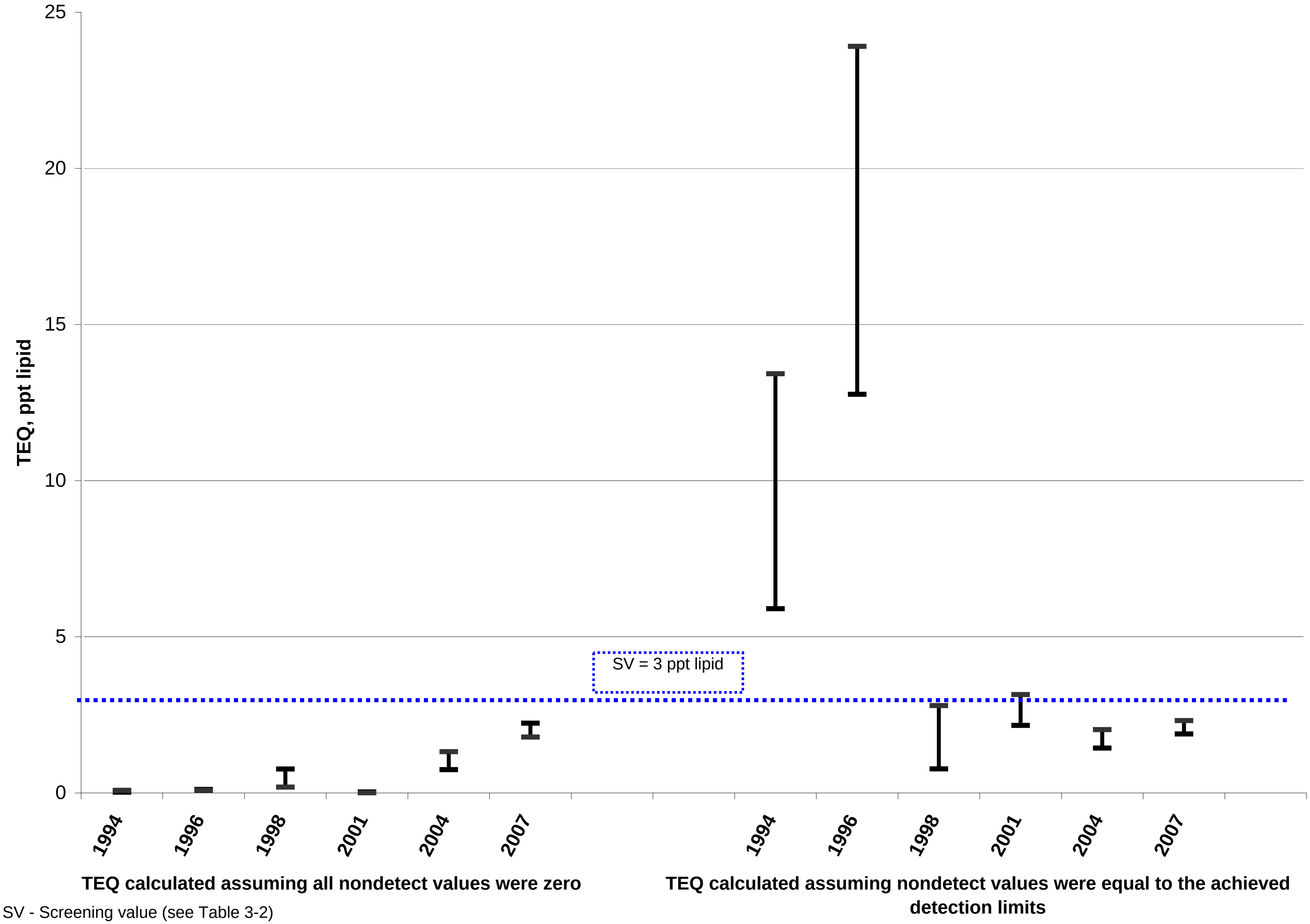


Figure 4-28b: PCDDs/PCDFs in Hay: Kingsbury Dairy Farm Pre-Operational ('94) and Operational Phase ('96, '98), Pond 3 Farm and Background Operational Phase ('01, '04) and Arthur Johnson Farm ('04)



Notes:
P3F = Pond 3 Farm
BK = Background
AJF = Arthur Johnson Farm
KDF = Kingsbury Dairy Farm
Concentrations are the average of detected values.

Figure 4-29: Lipid Normalized PCDDs/PCDFs in Milk: Pre-Operational ('94) and Operational Phase ('96, '98, '01, '04, '07) TEQ Ranges



SV - Screening value (see Table 3-2)

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Figure 4-30: PCDD/PCDFs in Milk

Figure 4-30a: PCDDs/PCDFs in Milk: Arthur Johnson Farm (Operational Phase '07)

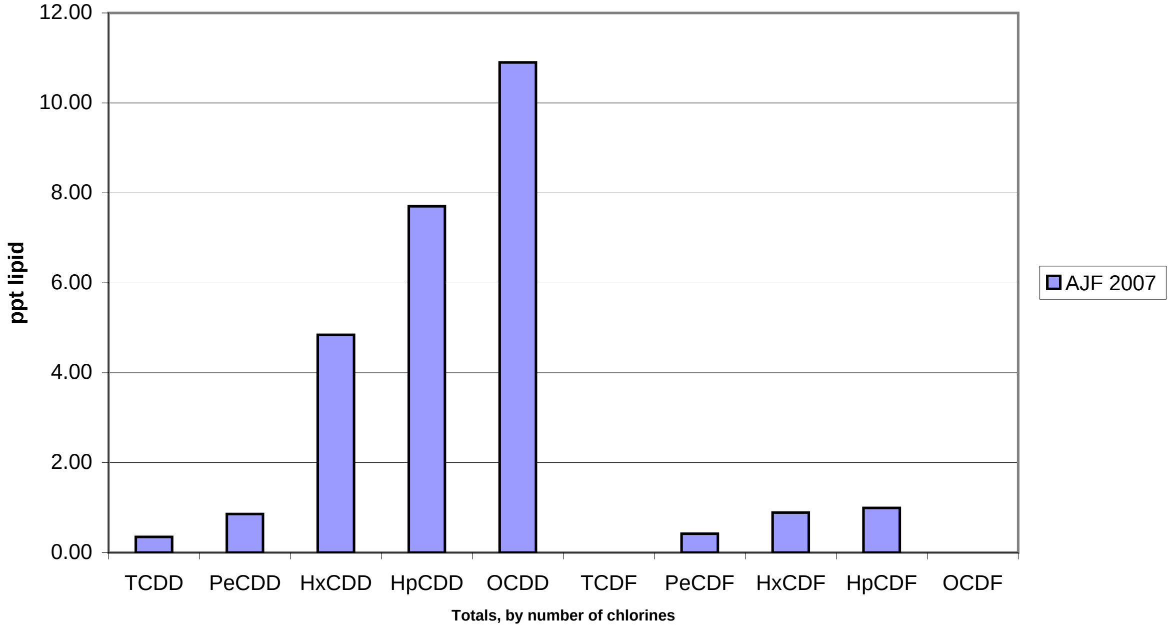
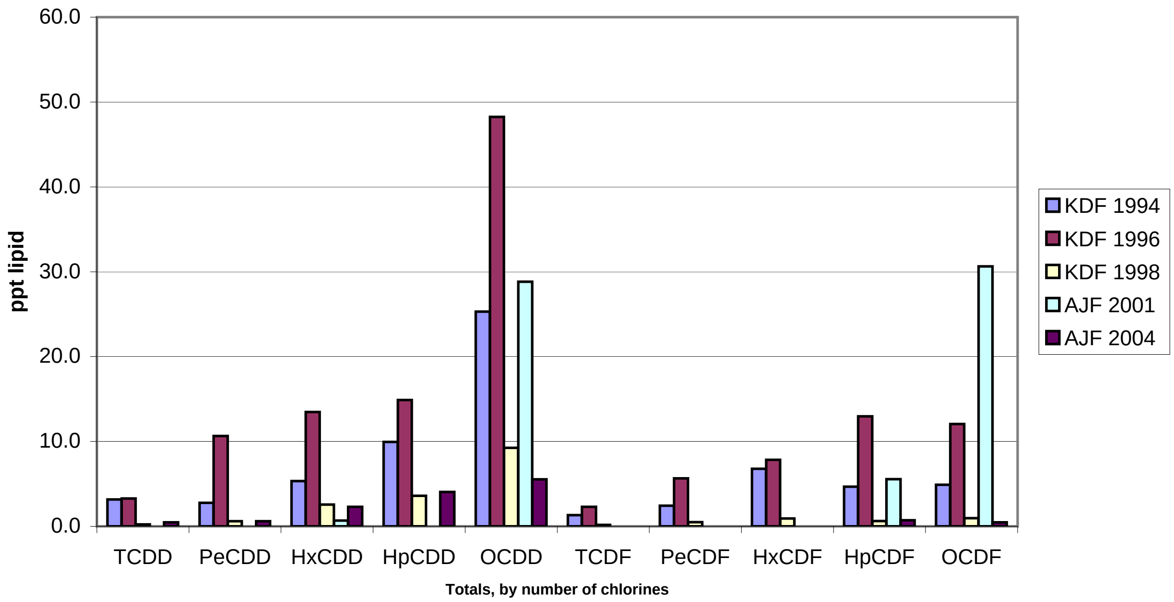


Figure 4-30b: PCDDs/PCDFs in Milk: Kingsbury Dairy Farm Pre-Operational ('94) and Operational Phase ('96, '98), and Arthur Johnson Farm Operational Phase ('01, '04)



Notes:
AJF = Arthur Johnson Farm
KDF = Kingsbury Dairy Farm
Concentrations are the average of detected values.

5.0 Summary and conclusions

The 4th operational phase non-air media sampling event was conducted in June, 2007 to continue the long-term monitoring program for the Montgomery County RRF. As part of this program, three farm ponds were sampled for surface water, a prey fish (whole body and fillet), and a predatory fish (whole body and fillet). One farm was sampled for cow's milk and hay. Hay was also collected from a farm located very close to (within) the RRF facility air emissions maximum deposition zone (Pond 3 Farm), at the dairy farm (Arthur Johnson farm), which is slightly farther away to the northeast of the maximum deposition zone, and a location outside the influence of RRF air emissions ("background" site in Lucketts, VA). In addition, sediment from the farm ponds was re-introduced to the monitoring program for 2007. Pond sediment had been sampled in the pre-operational and 1st operational phase monitoring programs. All samples were analyzed for the seventeen PCDD/PCDF congeners and combined to calculate the TEQ values in accordance with World Health Organization TEFs and a select group of seven metals (arsenic, beryllium, cadmium, chromium, lead, mercury, and nickel). In order to isolate the uncertainty in calculated TEQ values introduced by changes over time in laboratory detection limits, TEQ values were calculated both assuming zero for non-detected congeners and assuming concentrations equal to the method detection limits for non-detected congeners. Surface water was analyzed for water quality parameters (pH, specific conductance, dissolved oxygen, and temperature) and total hardness (as $CaCO_3$) and the biotic media were analyzed for percent lipid (i.e., percent fat). These data were compared to the existing set of historic data collected in previous monitoring programs. These historic data include pre-operational baseline data (1994-1995), and data from the first three operational phase events (1996 –1998, 2001, and 2004).

5.1 Summary

Based on a review of the data, the following is a summary of findings:

<u>Surface Water</u>

- Pond 2 water quality measurements of pH and dissolved oxygen content were found to be in the normal range and the pond seems to have recovered from the poor water quality readings observed during the 2004 program. The improved water quality of the pond was consistent with improved fishing compared to 2004 as discussed below.
- With the exception of lead and nickel, Pond 2 surface water concentrations of metals were consistent with, or lower than, historical data collected in previous monitoring programs. Lead concentrations were slightly higher than the data from 2004 and 2001 monitoring programs but lower than the 1994 (pre-operational) and 1996 (1st operational phase) programs. Nickel concentrations were slightly higher in 2007 compared to 2004, however, the 2007 nickel concentrations were lower than 2001 concentrations as well as 1994 and 1996 data.
- Regardless of the treatment of non-detected congeners, TEQ values are either comparable with or lower than historical sampling results; there is no evidence of any upward trend in PCDD/PCDF (as TEQs).

<u>Sediment</u>

- Sediment was sampled from the farm ponds in 2007 for the first time since the 1994 pre-operational monitoring program and the 1996 1st operational phase monitoring program (i.e., only 3 sampling periods thus far).
- Pond 2 sediment concentrations of arsenic, beryllium, and mercury are comparable or lower than historic data collected in previous monitoring programs. Cadmium concentrations measured in

2007 are lower than in 1996, but comparable to 1994. Chromium, lead and nickel concentrations in 2007 are slightly higher than historic data collected in previous monitoring programs.

- Pond 3 sediment concentrations of arsenic, cadmium and mercury are comparable or lower than historic data collected in previous monitoring programs. Beryllium, chromium, lead and nickel concentrations measured in 2007 are slightly higher than historic data.
- Pond 5 sediment concentrations of arsenic, beryllium, cadmium and mercury are comparable or lower than historic data collected in previous monitoring programs. Chromium, lead and nickel concentrations measured in 2007 are slightly higher or comparable to historic data collected in previous monitoring programs.
- When assuming zero value for all non-detected congeners, the TEQ sediment concentrations appear slightly higher in 2007 than in previous years, however, when detection limits are included, the 2007 TEQ concentrations are either consistent with or lower than previous years. This is the case for all three ponds.
- Future periodic sediment sampling at these ponds is recommended.

<u>Fish</u>

- Trend analyses for the fish tissue evaluations have assumed that the fish collected are comparable across all sampling events. Fish may accumulate toxic chemicals at different rates, depending on factors such as age, size, feeding guild (i.e., predator or prey fish), temperature, stocking rates, pond size, population density, and amount of nutrition available to the fish. This variability and uncertainty is inherent in field tissue collection, and not all factors can be accounted for in any sampling program. The non-air monitoring sampling program has been designed to help control some of the variability. Fish have been collected from the same ponds throughout the sampling program. One prey species and one predator species have been targeted from each pond to demonstrate potential differences in accumulation of toxic chemicals in the fish based on feeding guild and size. Although fish age has not been determined for each fish caught, size has been measured. Finally, fish tissue data for dioxins have been adjusted to reflect the fat content of each fish (the lipid-normalization of the data), which helps control for the changing nutrition levels in the ponds.
- Consistent with improved water quality readings, Pond 2 fishing was improved compared to 2004 (eighteen bluegill sunfish were caught during the field effort).
- Pond 2 metals concentrations in whole body and fillet prey fish are comparable or lower than historic data collected in previous sampling programs. When assuming zero for all non-detects, the TEQs are slightly higher in 2007 than in previous years (’94, ‘96, and ’01). However, when including detection limits, the TEQ s for 2007 are lower than previous years.
- Pond 3 prey and predator fish fillet and whole body samples have concentrations of metals in 2007 that are comparable or lower than historic data collected in previous programs. When assuming zero for all non-detects, TEQ concentrations in fish, particularly largemouth bass, are higher than the data collected in previous years. Concentrations of detected PCDDs/PCDFs are comparable for prey fish but higher for predator fish in 2007 compared to previous years. Given that the observed TEQ increase in 2007 based on detected congeners is very low, 5-40 ppt (depending on the sample), these differences may be attributable to the natural variations in the ambient environment and/or to the effect of lowered detection limits in 2007. In addition, the largemouth bass sampled was the largest bass (17”) caught during the last three programs. A larger, older fish will have accumulated more PCDDs/PCDFs than a younger fish. When detection limits are included, the 2007 Pond 3 fish TEQs are generally consistent with or lower than the previous years.

- Pond 5 prey and predator fish fillet and whole body metals concentrations are consistent with, or lower than, historic data with the exception of nickel in bluegill sunfish fillet, which is slightly higher than 2004 data. No data were available from 2001, 1996 and 1994 programs. In the case of whole body prey tissue, when assuming zero for all non-detects, the TEQ for 2007 are lower than those calculated for 2004 but higher than the 1994 and 1996 values. However, when detection limits are included, the 2007 values are lower than all previous monitoring periods. In the case of predator fillets, when assuming zero for non-detected congeners, the TEQ for 2007 are slightly higher than the two previous monitored years. When detection limits are included, the 2007 TEQ values are slightly higher than the 2004 values, but substantially lower than in 2006. In the case of predator whole body samples, when assuming zero for non-detects, the 2007 TEQ values are consistent with prior years, but when detection limits are included, the 2007 TEQ values are either consistent with or lower than previous years.

<u>Hay</u>

- Metals concentrations in hay collected in 2007 from Pond 3 Farm are generally consistent with concentrations detected in previous sampling events for Pond 3 Farm and Kingsbury Dairy Farm. Metals concentrations collected in 2007 from Arthur Johnson Farm are comparable or lower than 2004 data, but consistent with concentrations in hay from Kingsbury Dairy Farm and Pond 3 Farm.
- Chromium and nickel concentrations in hay from the background location in Lucketts, Virginia appear to be higher in 2007 than in previous sampling events (2001 and 2004) and have consistently increased since 2001. This trend was not exhibited at either Pond 3 Farm or Arthur Johnson Farm. This, in conjunction with the findings of the dispersion/deposition modeling, indicates that other sources in the upwind direction are contributing these metals.
- In the case of hay collected at the Pond 3 Farm, when assuming zero for non-detected congeners, the 2007 TEQ results are slightly higher than in 2004 but either consistent with or lower than the 2001 results. When including non-detects, the 2007 TEQs for hay at this farm are lower than the 2004 results and substantially lower than the 2001 results. In the case of the Arthur Johnson Farm, which was sampled only in the 2004 and 2007 programs, regardless of the treatment of non-detects, the 2007 TEQ values are higher in the 2007 sampling period than in 2004. No trend is indicated by these two points, or by consideration of hay data from other farms.
- With respect to the three farms for which hay samples were obtained in three program monitoring periods (Kingsbury Dairy Farm ’94, ’96, ’98; Pond 3 Farm ’01, ’04, ‘07; and Background ’01, ’04, ’07), TEQ values for succeeding years tend to be either consistent with or lower than prior years, and this is the case regardless of the treatment of non-detected congeners.
- The PCDDs/PCDFs detected in hay in 2007 at Pond 3 Farm were predominantly HpCDDs and OCDD, with some HpCDFs and OCDFs (Figure 4-28a), which are the least toxic of the dioxin/furan congeners. Hay samples collected previously from Kingsbury Dairy Farm (Figure 4-28b) also contained predominantly HpCDDs and OCDDs and a variety of tetra- through octa-chlorinated PCDDs/PCDFs at very low levels.
- Samples from Arthur Johnson Farm and the background location were dominated by the higher chlorinated, less toxic congeners, particularly OCDD. This congener pattern is consistent with the hay samples from the Kingsbury farms and Pond 3 Farm in this study.

<u>Milk</u>

- Metals concentrations in milk from 2007 are consistent with, or lower than, historic metals concentrations from previous monitoring programs.

- Assuming zero values for all non-detected congeners yields an apparent increase in monitored TEQ, however the reverse is true when including the detection limits in the calculation of TEQs. While there is no discernable trend in this respect, the consistency of the TEQ values for 2007, calculated with and without detection limits, reflects the high degree to which congeners are now able to be detected.
- PCDD/PCDF detected in the 2007 data were predominately the higher-chlorinated of the dioxin congeners (HxCDD, HpCDD, and OCDD). The lower-chlorinated dioxin congeners (PeCDD and TCDD) were also present, but furan congeners were not detected (Figure 4-30a). Milk collected in previous sampling events, particularly 2001 Arthur Johnson Farm milk, indicates little to no presence of the lower chlorinated dioxin congeners, and an increased presence of all furan congeners (Figure 4-30b). The presence of TCDD and PeCDD in the 2007 milk samples would help explain any higher calculated TEQ values for milk in 2007, since these congeners are more toxic and have high TEFs (Table 3-1).
- Differences between 2001-2007 and 1994-1998 data could also be associated with the change in sampling locations (milk samples in 2001, 2004 and 2007 were obtained from Arthur Johnson Farm while 1994 and 1996-98 samples were collected from Kingsbury Dairy Farm).

5.2 Conclusions

Metals

In general, metals in non-air media collected during the 2007 sampling program are consistent with concentrations from previous sampling events. Slight variation over time has been observed; some metals were higher in 2007 than in 2004, but were lower than 2001. These small variations are common and expected in natural systems. Slight variations in measured concentrations will be associated with the randomness of samples, the time of year a medium is sampled, and fish age for example.

Sediment was sampled from the farm ponds in 2007 for the first time since the 1994 pre-operational and the 1996 1st operational phase programs (three sampling periods), making trend analysis not yet possible. The sediment concentrations of mercury in 2007 were either comparable to, or lower than, historic concentrations, while slight increases were observed in chromium, nickel and lead. As discussed earlier, mercury is emitted in far greater amounts (more than seven times greater) than chromium, nickel and lead from the RRF stack (see Figure 4-1). Since 2007 mercury concentrations in pond sediment are comparable to, or lower than, historic data collected in previous monitoring programs, there is no evidence to suggest that the RRF emissions have contributed to the observed increase in chromium, lead and nickel concentrations in sediment. Given the consistent increase in chromium and nickel in the hay from the background location (which is not influenced by RRF emissions), an increase in chromium and nickel concentrations in pond sediment may be attributable to regional ambient air levels and not related to emissions from the RRF. Continued sampling of pond sediment for metals in future programs will provide additional data for trend analysis.

Dioxins/Furans (PCDDs/PCDFs TEQ)

PCDDs/PCDFs measured in the non-air media in 2007 were generally comparable to or lower than previous sampling events. Better detection limits were achieved in 2007, continuing a trend in improving laboratory detection limits over time. As a result, the TEQ concentrations, calculated using only detected congeners (that is, assuming zero for non-detected congeners), appear elevated compared to some prior years for some media, such as sediment, Pond 2 sunfish, Pond 3 largemouth bass, Pond 5 largemouth (fillet only), and hay. However, when the TEQ values are calculated including detection limits, the effect is reversed and 2007 results are generally either consistent with or lower than prior years.

The same is true in the case of milk. Assuming zero values for all non-detected congeners yields a small increase (less than 1-2 ppt) in PCDD/PCDF concentrations in milk from 2001 to 2007. Such small differences can be due to natural variations in samples. However, when including detection limits, the 2007 TEQ values are either consistent with or lower than prior years. The need to move sampling location compounds uncertainty. Since the Kingsbury Dairy Farm discontinued dairy operations after 1998, any real differences between 2001-2007 and 1994-1998 data could also be associated with the change in sampling locations. Milk samples in 2001, 2004 and 2007 were obtained from Arthur Johnson Farm, while 1994 and 1996-98 samples were collected from Kingsbury Dairy Farm. Finally, changes in other influences such as animal feed (other than hay) and animal census were beyond the scope of the study.

Hay collected at the Arthur Johnson Farm in 2004 and 2007, suggests a slight increase in TEQs if one assumes zero for non-detects, and TEQs either consistent with or slightly increased if detection limits are included. It is not possible to discern if this represents any trend given the limited data available thus far from this farm (only two sampling events). Also, while PCDD/PCDF concentrations in milk at the same farm increased slightly, the metals did not. Comparing all monitoring years, and disregarding the shift in farm location, TEQs in hay are either consistent with prior years (assuming zero for non-detects) or declining (including detection limits).

The pattern of congeners in both milk and hay from Arthur Johnson Farm do not reflect the pattern of congener emissions from the RRF. The RRF dioxin/furan emission profile (see Figure 4-15) shows the highest emitted congener is OCDD, but all congeners are present, including the lower chlorinated congeners (tetra- through hexa-chlorinated dioxins and furans). These lower chlorinated congeners are more bioaccumulative than the OCDD (see U.S. EPA (1999b, 2005b) Bioconcentration Factors listed Table 5-1). These values represent the uptake rate of dioxin/furan congeners from soil to plants (Soil to Plant BCFs) and the uptake/biotransfer rate of the congeners from environmental media (i.e., soil, water, food, air, etc.) into cow's milk (Ba Milk). Any tissues potentially impacted by the RRF emissions would be expected to have levels of TCDD, TCDF, PeCDF and HxCDF reflective of this fact. This is not the case for either milk or hay from Arthur Johnson Farm. The milk samples (see Figure 4-30a) have no detects for TCDF and OCDF, very low concentrations for the other furan congeners, and TCDD is the lowest detected dioxin congener. Hay samples (see Figure 28a) do not have any detects of TCDD, TCDF, PeCDF or HxCDF, all of which are more bioaccumulative than OCDD. Therefore, there is no evidence indicating that the apparent increase in dioxin concentrations in milk and hay are linked to the RRF.

In summary, based on the available data (for PCDDs/PCDFs and metals) collected in the non-air media during the pre-operational phase (1994) and three operational phases (1996-98, 2001, 2004 and 2007). 2007 concentrations of PCDD/PCDF and metals are generally consistent with, or lower than, historical concentrations in previous monitoring program years (1994, 1996-98, 2001 and 2004), and there does not appear to be any evidence to suggest any increases in environmental media are attributable to RRF emissions. Future monitoring should target the same analytes, media (i.e., fish species), and locations as those sampled in 2007. Laboratory methods and techniques should be adequate to ensure that MDLs within the range of those achieved in 2007 are met.

Table 5-1
Dioxin/Furan Bioconcentration Factors

Congener	Soil to Plant BCFs [1]	Ba Milk [2]
2,3,4,7,8-PeCDF	0.009	0.0051
2,3,7,8-TCDD	0.0056	0.0061
1,2,3,7,8-PeCDD	0.0052	0.0061
2,3,7,8-TCDF	0.0045	0.0064
2,3,4,6,7,8-HxCDF	0.0038	0.0039
1,2,3,7,8,9-HxCDF	0.0035	0.0039
1,2,3,4,7,8,9-HpCDF	0.0022	0.0020
1,2,3,4,7,8-HxCDD	0.0017	0.0023
1,2,3,7,8-PeCDF	0.0011	0.0055
1,2,3,6,7,8-HxCDF	0.0011	0.0039
1,2,3,7,8,9-HxCDD	0.00078	0.0039
1,2,3,6,7,8-HxCDD	0.00067	0.0039
1,2,3,4,7,8-HxCDF	0.00043	0.0039
1,2,3,4,6,7,8-HpCDD	0.00029	0.0014
OCDF	0.00009	0.0006
OCDD	0.000067	0.0029
1,2,3,4,6,7,8-HpCDF	0.000062	0.0020

Notes:
Congeners are sorted by increasing bioaccumulative potential.
BCF = Bioconcentration factor
Ba = Biotransfer factor
[1] USEPA 1999, Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities, EPA 530-D-99-001A August 1999
[2] USEPA 2005, Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities, EPA 530-R-05-006 September 2005

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7.0 Glossary

The following terms and phrases are defined specifically for interpretation in the Non-Air Media Monitoring for the Montgomery County Solid Waste Resource Recovery Facility

40 CFR Part 136: Part of the U.S. Federal Register, Part 136 defines the Clean Water Act.

1,2,3,4,6,7,8-HpCDF: A furan congener having seven chloride atoms.

1,2,3,4,7,8-HxCDD: A dioxin congener having six chloride atoms.

1,2,3,6,7,8-HxCDF: A furan congener having six chloride atoms.

1,2,3,7,8-PeCDD: A dioxin congener having five chloride atoms.

1,2,3,7,8-PeCDF: A furan congener having five chloride atoms.

2,3,4,6,7,8-HxCDF: A furan congener having six chloride atoms.

2,3,4,7,8-PeCDF: A furan congener having five chloride atoms.

2,3,7,8-TCDD: A dioxin congener having four chloride atoms, and the most toxic of the dioxins and furans.

2,3,7,8-TCDF: A furan congener having four chloride atoms.

Abiotic: Of or characterized by the absence of life or living organisms. The abiotic medium sampled for this Program is surface water.

Accumulation: Collection or amassing. In this report, the reference of accumulation is to the build-up of chemicals in the tissues of organisms, such as hay and fish.

Accuracy: The extent to which a given measurement agrees with the standard value for that measurement.

Amber: Amber bottles are dark brown and limit the amount of light to which a sample is exposed. Some chemicals, such as dioxins and furans, can change when exposed to light. Use of amber bottles limits the amount of change between sample collection in the field and analysis in the laboratory.

Ambient Conditions: The surrounding area or environment.

Ameliorate: To improve upon or make better under existing conditions.

Analyte Group: A pre-selected group of test parameters, such as dioxins or metals.

Analyte: A specific test parameter (chemical or compound).

Anomalous: Inconsistent; not like others.

Anthropogenic: Caused or produced by humans.

Aquatic: Living or growing in water. Examples of aquatic environments include wetlands, rivers, streams, ocean, and ponds.

AWQC: Ambient Water Quality Criteria

Baseline Data: Information such as media-specific chemical concentrations collected before operations that may cause an impact occur. Montgomery County collected baseline data before the RRF became operational.

Benthic Invertebrates: Invertebrates (animals without backbones), such as insects or crayfish, that live in the sediment.

Biomagnification: The accumulation of chemicals such as dioxins, through a food chain, where one organism eating another is subject to the biomagnification of the chemical.

Biomonitoring: The process of observing, detecting, or recording the operation of a biological system.

Biotic: Pertaining to life or living beings. Biotic media sampled for the Program are hay, milk, and fish.

$CaCO_3$: Calcium carbonate; a way measure water hardness is to measure calcium carbonate.

Calibrate: To set or check the graduation of a quantitative measuring instrument. To check, adjust, or determine by comparison with a standard.

Carcinogens: Chemicals that, at certain high concentrations and exposure, may cause cancer.

Chain of Custody: A documentation or “paper trail” of a sample, from collection through disposal.

Chlorinated: When a chemical contains a chloride atom (Cl-) as part of its make-up.

Chronic Criteria: Promulgated values that are protective over long term exposures.

Composite: To take many and bring together as one; such as taking many small fish and analyzing them as one sample.

Congener: A chemical in the same category as another. Congeners are related because of their make-up and are often different by the addition or subtraction of one atom.

Deposition: Where chemicals from the RRF discharge to the air (i.e., emissions) fall to the ground.

Detectable Difference: A difference in measurements that is obvious and undeniable.

Detection Limit: The lowest or smallest concentration that can be measured with a pre-determined accuracy. EPA uses 99% accuracy.

Dioxins/Furans: A group of related compounds (i.e., congeners) that contain different numbers of chloride atoms. Dioxins and furans are known to be carcinogenic.

Dissolved Oxygen: Dissolved oxygen is the amount of gaseous oxygen that is in water and available for fish and other aquatic organisms to use.

Dissolved Species (Metals): Metals in water that are in a “free” or available form; the fraction of metals that are dissolved is the concentration of that metal that is potentially toxic because organisms can absorb these metals into their tissue.

Dry Ice: A frozen gas (carbon dioxide) that is used to keep samples frozen in transport. The temperature of dry ice is below zero degrees Fahrenheit (F), and is colder than regular ice (32 degrees F).

Duplicate: A QA/QC sample that is created by splitting a single sample into two unique samples for analysis.

Ecosystem: The inter-relationships of many organisms living together at one time and one place.

Emissions: An act or instance of emitting, to send forth or to discharge.

Environmental: Pertaining to the air, water, minerals, organisms, and all other external factors surrounding and affecting a given organism at any time.

Enzyme: Any of various proteins, pepsin, and amylase, originating form living cells and capable of making it easy to produce certain chemical changes in organic substances.

Epibenthic Organisms: Organisms that live on top of the sediment.

Essential Nutrients: A group of chemicals or compounds that are necessary for the health and well-being of living organisms. For instance, calcium is an essential nutrient for human bone production.

FDA Action Level: A value developed by the U.S. Food and Drug Administration (FDA) indicates a chemical concentration in food (e.g., mercury in fish) that is considered safe for human consumption. When concentrations exceed the action level, advisories may be posted warning the public to limit the amount of that food type ingested.

Fillet: A boneless and skinless piece of fish. This is the edible portion of the fish samples, and is considered the most appropriate for the evaluation of potential risks to human health and ingestion of fish.

Fingerprint: A characteristic or pattern of a group of compounds that can are unique to the source.

Food Chains: A series of organisms interrelated in their feeding habits, the smallest being fed upon by a larger one, which in turn feeds a still larger one.

Gaseous: In the vapor form, such as fumes.

Hepta: Having seven. Such as hepta-chlorinated compounds that have seven chloride atoms.

Herbaceous: Of a plant or plant part, not woody. Examples of herbaceous plants include wildflowers, grass, hay, and crops (e.g., peas and tomatoes).

Hexa: Having six. Such as hexa-chlorinated compounds that have six chloride atoms.

Hexane: An organic chemical that is used to clean sampling equipment or tools. Hexane is a solvent that can dissolve other organic chemicals that are not soluble in water (such as oils).

Higher Trophic Level Predator Fish: Species typically found higher on a food chain with carnivorous (meat-eating) feeding tendencies. Due to their feeding habits and longer lives, higher trophic level fish tend to accumulate more chemicals in their tissues over the course of a lifetime.

Inorganic: Those chemicals that are not organic. Examples include most metals and metal compounds.

Lentic: Pertaining to a body of water that is not moving, as a pond or lake.

Limits of Quantitation: The level above the method detection limit at which reliable quantitative measurements can be made.

Lipid Normalized: A way to express a concentration to explain the amount of a chemical present per unit of fat (lipid) rather than unit of body weight.

Lipid: Any of a group of organic compounds comprising fats, waxes, and similar substances that are greasy, insoluble in water, and soluble in alcohol.

Literature Background Levels: Values published in various sources, such as books and journal articles, that describe concentrations of chemicals in media sampled in areas outside the direct influence of the source of contamination.

Matrices: Plural of matrix.

Matrix Spike/Matrix Spike Duplicate: QA/QC samples that are used to provide checks on the laboratory. Known amounts of chemicals are spiked into each matrix and the "recovery", or measurement of added chemical, is quantified.

Matrix: A term used in a laboratory to define a form, such as liquid or solid.

Media: Describes components of the surrounding environment. Examples of environmental media are air, water, soil, fish, milk, hay, and sediment.

Method Detection Limits (MDLs): An estimate of the detection limit the laboratory can achieve. MDLs are generated using statistics following specific EPA guidance, and are the lowest concentration (greater than zero) that the laboratory can measure and report 99% confidence. To calculate an MDL, laboratories test known concentrations of a chemical (i.e., arsenic) usually in a laboratory pure matrix and, based on the results, calculate a concentration that is the lowest achievable concentration for that chemical in that medium, for that laboratory for the equipment used. MDLs vary over time and between labs.

mg/kg: Milligrams per kilogram, or number of parts in a million parts.

Monitoring: The process of observing, detecting, or recording the operation of a system, such as the potential accumulation of chemicals in abiotic media and the food chain.

Multi-Media: More than one medium. For the RRF Monitoring Program, multi-media refers to fish tissue, hay tissue, cow's milk, and water.

Multiplier: A number by which another number is multiplied.

Nitric Acid (HNO_3): An acid used to preserve a sample for metals analysis.

Octa: Having eight. Such as octa-chlorinated compounds that have eight chloride atoms.

Organic: Refers to a class of chemical compounds that include carbon in their composition. Organic compounds are often derived from animal or plant material (e.g., fossil fuels are organic compounds; they are derived from animal and plant material and contain carbon. The burning of fossil fuels produces other organic compounds).

Outlier: A value that is inconsistent; outside the normal collection, or distribution, of data.

Particulates: Air-borne solids, such as dust.

PCDDs/PCDFs: A generic term to indicate all dioxins and furans as a group; polychlorinated dibenzo-dioxins (PCDDs) and polychlorinated dibenzo-furans (PCDFs).

Penta: Having five. Such as penta-chlorinated compounds that have five chloride atoms.

Persistent Pollutants: A certain group of chemicals that are known to reside in the environment without changing or degrading (i.e., breaking down into smaller components).

Pesticide Grade: A regulated rating that certifies a certain purity or lack of contamination.

pg/g: Picograms per gram; equivalent to parts per trillion (ppt).

pH: The symbol for the logarithm of the reciprocal of hydrogen atom concentration in gram atoms per liter, used to describe the acidity or alkalinity of a chemical solution on a scale of 0 (more acidic) to 14 (more alkaline).

Polychlorinated: Refers to having more than one chloride (Cl^-) atom in the structure of the compound. Polychlorinated compounds are often quite toxic to human health.

ppb: Parts per billion; equivalent to micrograms per liter (ug/L).

ppm: Parts per million; equivalent to milligrams per kilogram (mg/kg) or milligrams per liter (mg/L).

ppq: Parts per quadrillion; equivalent to picograms per liter (pg/L).

ppt: Parts per trillion; equivalent to picograms per gram (pg/g) or nanograms per kilogram (ng/kg).

Precision: Mechanical or scientific exactness expressing the degree to which further or repeated measurements yield the same or similar results. Can be expressed in terms of number of digits.

Primary Consumer Lower Trophic Level Fish: Species typically found lower on a food chain with herbaceous (plant-eating) feeding tendencies.

QA/QC (Quality Assurance and Quality Control): A planned and technical means of monitoring and measuring the correctness of a program. Duplicate samples, for instance, help measure the difference in chemical concentration that can occur within the same sample.

Quality Assurance Sample: Part of the QA/QC program, these samples include duplicates, blanks, and MS/MSDs and are used to help ensure the overall technical quality of the program and data.

Recreational Value: Of use and significance to humans.

Regulatory Guidelines: A set of rules created by a government agency, such as the U.S. Environmental Protection Agency.

Replicate: A QA/QC sample collected when one location is sampled twice at one time.

Sample Quantitation Limit: The actual detection limit achieved by the laboratory on each unique sample analyzed.

Saturation: The maximum concentration that is stable in solution. Saturation of dissolved oxygen in water is a function of many things, including temperature, pH, and atmospheric pressure.

Scientific Collection Permit: A permit granted by a state or federal agency allowing for the collection of specimens to be used for credible research or study.

Screening Levels: A generic term used to categorize chemical concentrations that indicate a particular level that may or may not be a regulation, such as the FDA Action Level, or U.S. EPA water quality criteria.

Seine Nets: A type of net used to collect fish. Seine nets have weights on one side and floats on the other, so that the net hangs vertically in the water.

Specific Conductance: The measure of the ability of electrons to move through a medium. Specific conductance can change over time and season in ponds.

Spiked: The introduction of a known amount of a chemical into a medium, Spiking samples is used to help laboratories calibrate instruments and equipment.

Standard Deviation: A statistical value that defines the consistency or inconsistency of a group of numbers in relation to the average.

Stratification: To be arranged or separated in different configurations. Water bodies such as the farm ponds, will naturally separate vertically by a distinguishing temperature gradient during certain months of the year. The stratification occurs due to differences in surface and bottom temperature.

Students *t* Factor: A value from a table of known values, used in statistics to estimate probability.

Surrogate: A substitute.

Suspended: Not dissolved, but floating above the bottom.

Taxonomy: The science dealing with the description, identification, naming, and classification of organisms. Taxonomy have several tiers, from Kingdom (i.e., animals vs. plants) to Species (i.e., bullhead catfish vs. channel catfish).

Terrestrial: Of or pertaining to land as distinct from water. Examples of terrestrial environments include forests, lawns, and fields.

Tetra: Having four. Such as tetra-chlorinated compounds that have four chloride atoms.

Tissue Residue: The measure of the amount of chemical in biotic tissue.

Toxic Equivalency (TEQ): The sum of the concentrations times their respective TEF. The TEQ is the concentrations that presents the total toxicity of a group of compounds. Specific to dioxin-like compounds.

Toxic Equivalency Factors (TEF): A set of multipliers used with a number of chemicals with different levels of, but a similar mode of toxicity. TEFs weight the toxicity of a chemical against the most toxic of the group of chemicals. For instance, if compound A is the most toxic and compound B is 1/100 as toxic, then the TEF for B would be 0.01.

Toxic: Hazardous; poisonous.

Trend Analysis: The mathematical study of the nature of general courses or prevailing tendencies, such as the increase or decrease in chemical concentration over time.

Trophic Level: Pertaining to nutrition at a biological stage or interaction. Trophic levels indicate the type of food ingested, and position of the organism in the food chain. Food chains include primary producers (i.e., plants) that get nutrition from the sun and other abiotic means, herbivores that consume plants, and omnivores that consume animal and plant material. Carnivores (meat eaters) have several levels, from lower level carnivores that consume herbivores, to upper level carnivores that consume other carnivores.

Water Column: The area of the water between the surface and the sediment.

Wet Weight: The weight of tissue as it is sampled; the weight of the fish.

Whole Body: Whole body fish tissue refers to the measurement of concentration of chemical in the whole fish, rather than just edible tissue.